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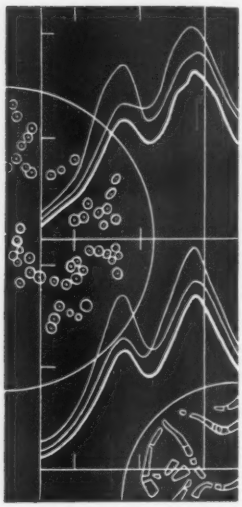

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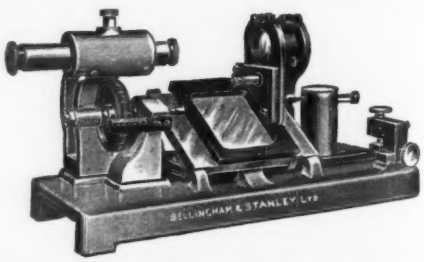

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SCIENCE, TECHNOLOGY AND MAN-POWER

THE report entitled "Notes on Science in U.S.A., 1954" recently issued by the British Commonwealth Scientific Organization, North America (see p. 76 of this issue), emphasized the continued preoccupation of the United States with problems of man-power and its increasing awareness of the challenge of the U.S.S.R. in this field. There is no doubt that Americans have been surprised by Soviet achievements, and this alone may result in an increased emphasis on the importance of fundamental science to the United States. More recently, Mr. Lewis Strauss, chairman of the Atomic Energy Commission, has expressed the opinion that the United States is rapidly falling behind the Soviet Union in training engineers and scientists, and that in ten years it might be hopelessly outstripped. The United States, he said, is turning out less than half the number of scientists and engineers it requires, and while there are about a million trained scientists and engineers in the Soviet Union and in the United States, only about 35 per cent of those in the United States are working at their profession. Last year the United States had about 23,000 science and engineering graduates compared with the Soviet Union's 53,000, and between 1950 and 1960 the Soviet Union was expected to produce 1,200,000 trained engineers and scientists compared with the United States 900,000. Moreover, 250,000–400,000 high-school students in the United States are being taught mathematics and science by teachers not trained to teach these subjects.

Such comparisons must be accepted with reserve and taken as indicating no more than trends, for the supply of professional personnel, and to a great extent its qualitative characteristics, depend upon the ability of an educational system to adjust itself to the changing needs of a society and upon the ability of that system to train a sufficient number of persons for a variety of specialized tasks. They depend, accordingly, both upon the nature of the educational system and upon the nature of the society which it serves. These must both be considered in attempting any comparisons of this kind, and even as between Great Britain and the United States figures can be very misleading if allowance is not made for such qualitative differences.

The difficulty is particularly acute in comparisons with Soviet Russia, and this is brought out well in the scholarly study of the availability and growth of the specialized man-power resources of the U.S.S.R. carried out by Mr. Nicholas De Witt under the auspices of the National Academy of Sciences—National Research Council, with the support of the National Science Foundation*. Mr. De Witt examines the evidence provided by the Soviet educational effort during the past twenty-five years which, because the type of training given aims definitely at preparing a specialist in a narrow field of professional activity, thus diminishing the opportunities of changing his professional occupation, is more useful for the purpose than the census enumeration or statistics of the employment of specialists. The Soviet policy of placing graduates in jobs coinciding with their field of formal training and their occupational specialities, and various totalitarian control measures, act in the same way.

Despite the pitfalls to which he directs attention, Mr. De Witt believes that it is possible to gain a fairly accurate idea of the general position in the Soviet Union; and apart from this his several chapters give clear and concise accounts of the general setting of the Soviet educational system—of primary and secondary education and of secondary semi-professional training—before he deals specifically with higher education and professional training, with research training programmes and advanced degrees and, finally, presents his conclusions on the supply and quality of Soviet professional and specialized man-power. It is these latter chapters that are of most interest to the scientist and technologist, and they are relevant to the current discussion on the expansion of technological education in Britain and the problems that are indicated in the report on the recruitment of scientists and engineers by the engineering industry which the Advisory Council on Scientific Policy has now released*. The earlier chapters, nevertheless, should not be overlooked. They bring out the major premises on which Soviet educational philosophy rests: the reliance on the central planning of education and research to advance science and technology; the belief that scientific and educational effort are primarily to be directed to the advancement of the national interests; and the static view of human life, of nature and of the universe, which leaves the teacher and the scholar with no further task than to demonstrate and apply established truth.

These premises go far to determine the strength or weakness of the Soviet man-power situation, and Mr. De Witt finds that in fact the expansion of professional training in higher educational establishments is not new and is unlikely in the future to be handicapped by a lack of satisfactory candidates from the secondary schools. Indeed, he expects a better and wider selection of candidates to be available in future; complaints, comparable with those voiced by some engineering firms in Britain, are already being made that school leavers are being directed to higher educational establishments when they should be directed to become skilled workers or craftsmen. It appears that there is a particular shortage of what would be termed in Britain technicians, and that a determined effort is being made to increase the numbers of such men.

* Soviet Professional Manpower: Its Education, Training, and Supply. By Nicholas De Witt. Pp. xxviii+400. (Washington, D.C.: National Science Foundation, 1955. Copies obtainable from U.S. Government Printing Office.) 1.25 dollars.

* Office of the Lord President of the Council. Advisory Council on Scientific Policy: Committee on Scientific Manpower. Report on the Recruitment of Scientists and Engineers by the Engineering Industry. Pp. 31. (London: H.M. Stationery Office, 1955.) 1s. 3d. net.

Mr. De Witt gives a fairly full general account of the thirty-three Soviet universities, which together have only accounted over the past twenty-five years for 8–12 per cent of the output of higher education graduates, most of whom come from the 758 institutes that give no general education and teach enough theory to permit the acquisition of applied knowledge in a given field. Thus they differ sharply from the basis on which even technical education is organized in Britain; but De Witt thinks it probable that in the universities the undergraduate chemist, for example, probably receives a training comparable with, but more extensive than, that in American universities, although there may be reservations on the teaching of selected topics. About half the Soviet students graduate with a major in the humanities and social sciences, and the other half with a science major. Moreover, there seems to be some correlation between academic performance and the positions to which graduates are assigned—the best going to research and those only average into school teaching.

Advanced degrees in the U.S.S.R. are obtained in research institutes as well as in regular higher educational establishments, and up to 70 per cent of them are obtained in scientific fields; while, even more than in the United States, those who acquire such degrees tend to remain in the academic field. Nevertheless, the ratio of professional technical workers in industry to production workers appears to have increased over the past twenty-five years by more than fourfold; and a substantial number of engineers are employed in administrative or managerial positions. Mr. De Witt suggests that in recent years the total number of trained engineers and the ratio of engineers to production workers in industry in the Soviet Union has been about the same as in the United States or even slightly higher. Likewise, the 160,000 scientists estimated as in the U.S.S.R. in 1952 is about four times as great as in 1930, and of these more than a third held advanced degrees.

When all allowance is made for the many reservations which Mr. De Witt emphasizes, he believes that higher education is more accessible in the United States than in the U.S.S.R., and for 1953 he gives the number of those with completed higher education as 5·8 million and 2 million, respectively. In engineering, medicine, agriculture and like fields, however, the U.S.S.R. had as many as, or even more trained men than, the United States: for example, about 500,000 professional engineers compared with 530,000 in the United States; about 280,000 physicians (but only 20,000 dentists) compared with 195,000 (and 90,000 dentists); and 170,000 agriculturists compared with 150,000. In proportion to the population, the number of trained professional men is lower in the U.S.S.R. than in the United States, but higher in relation to the workers not engaged in agriculture. Moreover, of the two million teachers, only about 37 per cent had completed higher educational courses, compared with 70 per cent of the 1·4 million teachers in the United States; and in 1952 there were only 90,000 teachers in higher educational establishments compared with 210,000 (in 1953) in the United States.

Figures such as these need to be kept in mind in comparing the man-power situation in the Soviet Union with that elsewhere, and its orientation primarily to the training of specialists in engineering, agriculture and medicine, and in considering the rather alarmist picture which Lord Simon of Wythenshawe presented recently in his annual report to the Court of the University of Manchester. At present, Lord Simon said, Britain is turning out only roughly half as many scientists and technologists per thousand of population as the other great powers, or roughly a fifth of the number produced by America and an eighth of the number produced by the U.S.S.R. Those figures do not agree with Mr. De Witt's; but much more important than any such comparison is a sound estimate of Britain's own man-power requirements and her available resources to meet them. We need some reasonable estimate of the country's needs for scientists and technologists of particular kinds, and of the supporting technicians. It is only on that basis that we can wisely begin to plan both how to provide the necessary supply, and also the measures to ensure that effective use is made of what at best is always a limited resource and unlikely ever to be in excess of demand.

There is even yet very little accurate information as to Britain's real needs, which may well differ from the apparent demand. Last spring, Sir Harold Hartley estimated the number of research scientists in Britain as about 58,600, a figure which may be compared with a total of 90,000 scientists which the increased output of 5,000 qualified scientists a year recommended by the Barlow Committee in 1946 was expected to achieve by 1955. The report which has just come from the Committee on Scientific Manpower of the Advisory Council on Scientific Policy covers only the engineering industry, and it indicates rather the difficulties with which the problem bristles. Statistically, it examines the recruitment of scientists and engineers by some fifty engineering firms, the average annual intake of which during 1951–53 was 7,156. Of these, 935 possessed first degrees (mainly technologists), 39 higher degrees and 70 first degrees in other subjects. Since university first degrees in engineering awarded to internal students averaged 2,300 over the period, and the nationalized industries took 203, while a considerable proportion found employment in the Civil Service, local government, teaching and the Atomic Energy Authority (some firms complained of intense competition from the Civil Service and the Atomic Energy Authority), the inquiry covered some 50 per cent of industry's intake of engineering graduates from the universities, and the total recruited was 25 per cent below the number required.

The Committee recognizes that this figure may be misleading and may even be an under-estimate, as the demand for such men is rising with the general level of industrial activity. Sir Ben Lockspeiser, for example, has strongly emphasized the need in Britain for greater numbers of research scientists, technologists and technicians, and for the infusion of management with a strong element of technological experience, particularly in relation to fully automatic

production engineering, the fruits of which will not otherwise mature. Many firms, moreover, remarked that too few of the graduates possessed real qualities of leadership and suggested that more attention should be paid to general education and the development of character. Most of the firms which co-operated in the inquiry stressed the importance of quality. It was also contended that engineering is not attracting its fair share of the available talent, and there was overwhelming support for recruitment at the first-degree stage except for research posts.

The University Grants Committee has already expressed concern at the conflict between the immediate need of industry for technologists and the claims of postgraduate work, and the Committee on Scientific Manpower quotes a passage from a note from the University Grants Committee to certain universities regarding special recurrent grants for higher technological education during 1954–57, which asks for a broad view of the national interest to be taken in planning postgraduate developments. For this reason, the plans for the expansion of the Imperial College of Science and Technology recently outlined by Dr. R. P. Linstead will be examined with special interest. The University Grants Committee does not consider it opportune to make any further suggestions about the development of technology.

That position, however, is only reasonable on the understanding that in the meantime the opportunity is taken to acquire, as a matter of urgency, much fuller and more accurate information about the requirements of Great Britain for trained man-power and its present distribution, and that plans are prepared, at least tentatively, to deal with the impending increase of some 50 per cent in the potential number of university students. By September 1956, when the universities have decided on their development plans for the quinquennium 1957–62, that increase will be hard upon us. Sir James Mountford estimates that by 1963–64 university numbers could be increased by 50 per cent without affecting quality if we can provide places and funds.

It is indeed reasonable that we should consider the shape and detail of further development in the light of the achievements of the past three years of the present quinquennium; but we should also at least be considering at this stage whether the national interest would not suggest that the universities should raise their standards and also that a large proportion of this impending 'bulge' should go to the technical colleges and not to the universities. Further, it must be remembered that, as Sir James Mountford points out, even the present expansion of British universities lags far behind what was planned for the seven years 1947–54 in terms of new building. Within that period expenditure of some £56 million on new building was approved. While costs have risen steeply, only £22·5 million was actually expended. As against the £80 million that the University Grants Committee stated in July 1946 would be required for new sites, buildings and equipment during the decade 1947–56, up to the end of July 1952 Sir James estimates that, in terms of 1947 prices, no more than £10 million had been completed.

This gives force to his contention that the expenditure of £40 million on university building in Britain during the next five or six years would give double the return to the nation of twice that sum later. The fear that the expansion of higher technological education might be detrimental to the interests of certain sections of the engineering industry noted in the report on recruitment by that industry did not impress the Committee which prepared the report; but it points to the need for some closer inquiry as to the balance to be struck between technical and technological education. Industry requires recruits from both sources—good graduates as well as good apprentices—and there is substance to-day in the argument that, under present social and taxation conditions, industry may draw in as apprentices boys of leadership and ability from middle-class homes with a long tradition of responsibility who formerly would have entered the university.

None the less, there is undoubtedly an increasing tendency for the ablest boys and girls to go to the universities, and the chances of recruiting outstanding talent except from such sources are diminished by the whole trend of educational and taxation policy. There is this to be said, moreover, for expediting as a matter of urgency the plans for new university building set in train nearly ten years ago: their execution, apart from permitting in due course a temporary increase of perhaps 30 per cent in the number of students of science and technology, as the bulge passes from the secondary schools, could be used to effect a permanent rise in standards, through the additional laboratory and library facilities and the increase in number of teachers. If a determined attempt is made to ascertain the real national needs, plans already in being should provide much of the flexibility needed to meet those needs without any considerable modification or further expansion.

The essential conditions are not indeed in conflict provided, as the Committee suggests, the universities and industry consult, and industry both makes its needs known precisely and co-operates in meeting them. The universities must examine their undergraduate courses in engineering, technology and science, and ensure that they are not too narrow and specialized or too cramping to men and women of initiative and of wide and original interest. But the supply of good recruits for apprenticeship courses requires more attention than the Advisory Council on Scientific Policy or its Manpower Committee suggests, and in particular the position of the technical colleges may well be a key. If Britain is to solve her problems of scientific and technical manpower, she must make the best use of her resources in that respect. To do so means giving both the average and the brilliant student the type of education from which they can best profit; and perhaps it is not so much a large expansion in university and technological education, especially at the postgraduate level, that is needed, as a great increase in the number of students of average ability who

proceed to the technical colleges instead of, as at present, to the university. Nor is this view inconsistent with Sir Alexander Todd's suggestion that industry needs many more men with a good general science degree.

In this connexion, it is worth noting that Sir Eric Ashby has suggested that technology may hold the key to general culture. Unlike science, it involves an understanding of popular art and of commerce and psychology, something of morals and justice and some skill in the art of communication. It is the spirit of pursuit that matters, and we would be wise to explore such possibilities carefully. Further, there may be more substance in the criticism that the engineering research carried out at the universities is concerned with topics of little value to industry than the Committee on Scientific Manpower seems disposed to admit. All such matters are best discussed in the light of a review of the distribution of Great Britain's scientific effort, in terms not only of man-power but also of finance and materials, which should be a constant preoccupation of the Advisory Committee on Scientific Policy no less than of the Defence Research Policy Committee. The primary need is that these resources should be continually reviewed, not in relation to the efforts of other countries, but in relation to our own changing needs, in the broadest possible perspective. It is only in the light of such a factual survey that measures for the expansion of technical and university education or for any redistribution of effort and resources can be soundly planned.

RECENT ADVANCES IN NUCLEAR SCIENCE

Progress in Nuclear Physics

Edited by Prof. O. R. Frisch. Vol. 4. Pp. vii+379. (London and New York: Pergamon Press, Ltd., 1955.) 70*s*. net.

VOL. 4 of this series, offering a survey of various fields in nuclear physics, seems the most readable one of those published up to now. All the articles are of interest, the problems properly formulated and the English of great clarity, due no doubt to the pains taken by the editor. The topics dealt with are: photodisintegration experiments with nuclear emulsions (E. W. Titterton); scintillation spectrometer statistics (Ernst Breitenberger); meson phenomena and the meson theory (R. H. Dalitz); focusing in high-energy accelerators (T. G. Pickavance); isotopic spin and nuclear reactions (W. E. Burcham); heavy ions of high energy (D. Walker); nuclear properties of the very heavy elements (J. O. Newton); the preparation and chemistry of the transuranium elements (H. A. C. McKay and J. Milsted); and neutron spectroscopy (D. J. Hughes).

To pick out one or the other article for comment seems unfair, but one has one's preferences. The summary on photographic plate studies of the nuclear photo-effect (E. W. Titterton) is excellent, as it does not go too much into technical details but shows up the power of the photographic-plate method, discusses the main results and very thoroughly the theoretical implications. A particularly useful contribution deals with the statistics of the scintillation counter (E. Breitenberger). Those very versatile tools, the 'generating functions', are developed to the point where a physicist can use them, and the author has followed, with their help, the many statistical effects which influence the width of a spectral line caused originally by a monochromatic quantum radiation. It is to be hoped that this article, which seems more like a piece of research, will encourage physicists to treat their fluctuation problems with the help of generating functions. Another impressive piece of reporting comes from the pen of Prof. Burcham on the use of isotopic spin. The crystal-clear and didactically outstanding introduction to the, at first, abstract notion of isotopic spin is very valuable, since the concept is so very useful in low- and high-energy nuclear and meson physics. I would appeal to the theoretical physicists to study it closely and find out how not to create a potential mountain for the experimentalist when explaining theoretical concepts.

The two companion articles on the physics and the chemistry of the very heavy elements are very timely; but it is a pity that they were written just before a large mass of information was being declassified for the Geneva Conference. For a physicist it is fascinating to watch the chemist separate in cation-exchange columns such tough problems as mixtures of the rare earths or the actinide series (see p. 321). This section is of considerable interest to the chemist and the physicist. The printing and reproduction are excellent.

E. Bretscher

SEXUAL MORALITY

Sex and Morality

By Prof. Abram Kardiner. Pp. 274. (London: Routledge and Kegan Paul, Ltd., 1955.) 18*s*. net.

Homosexuality

By Dr. D. J. West. Pp. xiii+145. (London: Gerald Duckworth and Co., Ltd., 1955.) 15*s*. net.

IT is a surprising thing that we do not know for certain what is the normal psychosexual development of a human being, or even an animal in the wild. We know, of course, through Freud's patient researches, how human beings develop in our culture and, through anthropological investigations, we have some idea how they develop psychosexually in other cultures; but it is impossible to isolate man from his environment and discover how he would grow up uninfluenced by custom.

Prof. A. Kardiner, in his interesting book "Sex and Morality", points out various developments such as liberalism which made women feel they should be freer, the romantic movement which stressed equality, and finally feminism which urged that women should have careers the same as men. These were protests against previous oppression, but produced profound effects on morality. The invention of successful contraceptive devices and medical advances against venereal diseases freed women from moral impediments and tended to break down custom still further.

Women's attempt to escape from the kitchen and the home and to substitute a career for family life led to compromise and often failure. When there were children there was inevitably some rejection of them, and such rejection has a profound effect on development. It can lead to aggression, which may appear later so that the child becomes a juvenile

delinquent heading towards a life of crime. Maternal rejection can also lead to perversion such as homosexuality, or finally to neurosis.

In examining our culture and methods of investigating it, Kardiner discusses the work of Freud and Kinsey. He gives one of the best commentaries on Kinsey's work which have so far been published and, since he has done considerable anthropological work, is able to draw on his experiences to check his conclusions. Far from being purely negative, Kardiner's criticisms enable him to give sensible remedies for many of the troubles which endanger modern civilizations. His book is an interesting one and well worth reading for its forthright views, although not every psychiatrist will agree with them. It is a pity that it is not provided with a better index.

Dr. D. J. West's book on "Homosexuality" is more of a popular medical one and should be easily comprehensible to the non-medical reader. He gives a careful outline of every aspect of homosexuality. It is considered in different communities, including our own, and discussed from the point of view of different types with their effect in creating legal and social problems. Two 'typical' cases are given.

Dr. West examines the influence of the endocrine glands, inheritance and psychological factors in causation. He discusses the relationship of homosexuality to mental abnormality and concludes his work with a somewhat sketchy chapter on treatment and prevention. This suggests that he has not had much practical experience in the therapy of the homosexual.

Medically this is not a controversial book, and it is easy to agree with nearly all that he says; in fact, it is what many psychiatrists have been preaching for the past two decades. His outlook, however, is generous, kindly and reasonable, as one would expect from a medical man educated in psychiatry. The adverse criticism one is inclined to make is that he is over-cautious regarding treatment, which is well worth while in the less-severe cases. There are an excellent index and a long list of a hundred and sixty references in the bibliography. There is also a list of novels which have homosexuality as a subject.

CLIFFORD ALLEN

OUTLINE OF PARASITOLOGY

Introduction to Parasitology, with Special Reference to the Parasites of Man

By Prof. Asa C. Chandler. Ninth edition. Pp. xiv + 800. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 68*s*. net.

THE ninth edition of this book, which began its successful career as long ago as 1918, reflects on every page the remarkable advances in knowledge that have so greatly increased our control of animals parasitic in man and other hosts. The book has always been one of the most readable of all books on parasitology. Its author, Prof. Asa C. Chandler, has the gift of the graphic and imaginative phrase; he can put, often in a simple arresting sentence or two, the complex relationships of the parasite and its environment; and man, who has good reasons for thinking that he has conquered some, at any rate, of his parasites, is warned against patting himself too complacently on the back. "In spite of spectacular advances in our struggle with parasites," Chandler says, "it is obvious . . . that the battle is far from won. In 1947 Stoll made the startling estimate that there are in the world to-day 2,200 million helminthic infections [of man]—enough for one for every inhabitant [of the world] if they were evenly distributed". Nor is the author concerned with human parasites alone. He has extended, in this edition, the text that dealt in earlier editions with the parasites of domesticated animals. He also discusses the spirochaetes, rickettsias and filterable viruses that are transmitted to man by arthropods. A number of chapters or sections have been entirely re-written, and changes have been made on every page. These changes are the measure of the advances that have been made since the eighth edition appeared in 1949.

This, therefore, is not a reprint of a formerly successful book. Although the general plan of the book has not been substantially altered, the reader is given a new and up-to-date account of this subject, the importance of which the author so graphically describes in his introduction. The illustrations, formerly not adequate for so valuable a book, have now been greatly improved. They have, no doubt, enabled the author to lighten the text by transferring to the illustrations much of the morphological detail that some readers often find rather heavy going. Besides, it is precisely here, in conjunction with the drawings themselves, that one finds this kind of detail most convenient. Mr. George Newman, of the University of Texas Medical School, who drew most of the new illustrations, is to be congratulated on his work.

Another feature of the book is the fact that classification and taxonomy are given only in so far as they help the student to understand the general relationships of the major groups of parasites; but simple keys for the identification of arthropods are given, and these are set in small type, so that they can be omitted if the reader wishes to do this. The emphasis is on the biological aspects of the subject—on life histories, epidemiology, host-parasite relationships and the principles on which treatment and prevention are based.

References to the literature are given at the ends of the chapters, not all together at the end of the book, as many readers would prefer. A list of journals and books from which further information can be obtained will help the reader who is not familiar with the literature. The make-up of the book has certainly now acquired a new look; it is brighter and generally more attractive to read. This edition will undoubtedly hold for this book the place that former editions have given it.

G. LAPAGE

MODERN DAIRY FARM PRACTICE

Dairy Cattle

Selection, Feeding, and Management. By Prof. William Wodin Yapp and Prof. William Barbour Nevens. Fourth edition. (Wiley Farm Series.) Pp. xii + 420. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 38*s*. net.

DAIRY husbandry, depending on many branches of biology, changes as these sciences develop. During the past two decades these changes have been rapid and sometimes revolutionary in character. For example, before the Second World War artificial

insemination of cattle was little used in commercial dairy farming, whereas at present half the cows in England and Wales are bred by this method. The third edition of Yapp and Nevens's book issued in 1941 was therefore due for revision, and in the fourth edition the authors have greatly improved the book by completely re-writing the whole to include more recent experimental findings and modern trends in dairy farm practice.

The book remains primarily a student's text-book; but is written in a simple style and can be followed by a reader with little technical knowledge of the subject. Nevertheless, the book covers a very wide field including genetics, nutrition and physiology, and for teaching at university-level an expansion of those sections dealing with the technical background of the subject would seem to be desirable. It must be admitted that this would make the book more voluminous and less attractive to the practical man.

To the farmer and student in Britain, Yapp and Nevens's book will be very useful so long as the reader is familiar with the differences in milk production between the United States and Britain. Apart from Brown Swiss cattle in America, the breeds of dairy cattle are the same in the two countries. In other respects, however, there are differences. The social and economic background of milk production in the United States is the family farm. In that country the summers are warmer and the production of good-quality bulky foods is, on average, easier. Maize and lucerne can be produced in many areas with little risk of a light crop or of a poor-quality product. Since land is plentiful compared with Britain, milk production is often carried on with little purchased feeding-stuffs.

There are certain aspects of the subject that are important in Britain, but which apparently barely merit mention by Yapp and Nevens. One of these is the use of the electric fence for strip-folding grass and fodder crops. Another is the tactical use of nitrogenous fertilizers for flushing swards. However, these are exceptions; and if the differences in environment and differences in terminology and values are borne in mind, this new book on dairy cattle would still merit a place among the most useful half-dozen books on dairy husbandry for the British reader.

It is unfortunate that any book on dairy husbandry begins to be out of date as soon as it is published. Thus, the chapter on artificial breeding was written before the development of techniques using deep-frozen semen. The implications of these changes may be profound, but they must await the next edition; and it is hoped that the fifth edition may follow the fourth before the back-log of new developments becomes too great.

Arthur S. Foot

NORTH AMERICAN MOSQUITOES

Mosquitoes of North America (North of Mexico)
By Stanley J. Carpenter and Walter J. La Casse. Pp. vii + 360 + 127 plates. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1955.) 75*s*. net.

SINCE the publication of the comprehensive works of Howard, Dyar and Knab (1912–17), Dyar (1928) and Matheson (1944), our knowledge of North American mosquitoes has greatly increased, and recent literature on the subject has become vast and scattered; nevertheless, a great deal remains to be done. But before taking further steps, it is wise to pause and survey what has already been accomplished, and from such a survey to compile a summary which will enable us to see more clearly what still remains unknown. In this book the authors have presented such a summary. They have attempted to bring together in one volume much of the published knowledge on the mosquitoes of this region, and they have endeavoured at the same time to present the information in as concise and up-to-date a form as possible. They have also kept in mind the needs of the "systematic entomologist, the technician and the field worker engaged in mosquito control".

The first point is well covered, for all statements are fully documented, and throughout the text numerous references occur to the bibliography, which contains nearly eight hundred titles. Regarding other aims, it is well realized that scientific investigation of any organism demands, before anything else is started, that the identification of the organism be established beyond doubt. The authors have therefore first given a general account of the life-history of the mosquito and some instructions on collecting and preparing material for study. They then pass to descriptions of the external anatomy of all stages and the internal anatomy of the female. In classification they have closely followed the system of Edwards and have divided the family Culicidae into three sub-families—Dixinae, Chaoborinae and Culicinae. A rather full account is then given of the North American genera and species of the sub-family Culicinae, which includes all the true mosquitoes.

The descriptions of some hundred and forty species occupy three hundred pages or so, the names being arranged alphabetically under genera or sub-genera. Each description is illustrated with figures of distinguishing morphological features of the adult and larva of that species and is accompanied by brief notes on biology, geographical distribution (first in the world and then by States and provinces of North America) and on medical importance wherever this applies. In addition, keys have been constructed to assist in the identification of females, male terminalia and fourth-stage larvæ, and 127 females are figured on as many full-page plates. All this is rounded off with a systematic index of six pages.

The work is thus an entomological tool to be used rather than a book to be read, and the real value of a tool is only assessed in use. The systematic entomologist or the mosquito specialist may at first regret that the taxonomic niceties of variations among species and the relationships in species 'complexes' are not more fully treated. The technician may think that his side has received insufficient attention, and the field-worker engaged in mosquito control will not find a section devoted to his special activities. But, to include discussions on these matters would have made an already large book even larger, and might even have necessitated a two-volume work. The interested reader will find the titles of relevant publications in the bibliography.

It is clear that it was not the authors' intention to develop these aspects of their subject, but to concentrate first on the essential identifications, and then to provide a starting-point from which workers could proceed further. It is certain that not only those mentioned but also many other people will have frequent need to consult this book, and because of the convenient lay-out they will find it easy to use as a work of reference for some years to come.

Numerical Tables for Nuclear Physics

By Charles Noël Martin. (French and English Texts.) Pp. viii+258. (Paris: Gauthier-Villars, 1954.) Paper 36*s*. 9*d*.; cloth 44*s*. 11*d*.

THIS book is devoted solely to tabulations from a number of semi-empirical formulæ. The first half contains tables of nuclear masses, alpha and beta decay energies, etc., from von Weizsäcker's mass formula. All the computations were made by hand without benefit of a machine, and graphical checks were employed. I find it hard to believe that the computational effort put into this book by M. C. N. Martin is in any sense justified. The mass formula has already been extensively tabulated by Metropolis and Reitweisner in America and merits nothing more than a thorough exposition of its many defects.

M. Martin would have done a better service if he had himself confronted the formula with experimental fact, and would have realized that for this purpose, and especially for comparisons with beta-decay data, it is more useful to have tabulations of the parameters usually connoted by M_A, B_A, Z_A, δ_A. It does not seem to be generally appreciated even now that the reliable experimental data are confined exclusively to the trough of the mass valley, so that the parameters B_A and Z_A are relatively ill-determined; on the other hand, nuclei further removed from beta stability (and for which no experimental data are available) are high up the parabolic walls, and their masses and decay energies are particularly sensitive to correct choice of the parameter Z_A of most stable charge.

Many of the tables in the second half of the book are rather trivial and suffer from too extensive tabulation: that makes the book more expensive and more complicated in use. For example, the recoil correction Em/M arising in nuclear bombardments and in alpha decay can be speedily and accurately assessed with a slide-rule. So far as nuclear radii and geometrical cross-sections are concerned, it would suffice to tabulate the cube roots of A and A^2. On the other hand, Coulomb barrier heights in MeV. and the barrier penetration factors involve several steps in computation and are more usefully tabulated. To be just it is necessary to add that, given the need for a table of semi-empirical masses, then M. Martin's production is well presented, well illustrated with examples, and convenient to handle. J. S. STORY

Seismology

By Prof. K. E. Bullen. (Methuen's Monographs on Physical Subjects.) Pp. viii+132. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1954.) 8*s*. 6*d*. net.

THE small book under review is a worthy addition to the well-known series of "Methuen's Monographs on Physical Subjects". The chapter headings are as follows: the significance of seismology in physics; macroseismology; instrumental seismology; *P* and *S* waves; fitting elastic wave theory to the Earth; seismology and geology; seismic rays, phases and travel times; Earth models based on seismology; microseisms—seismology and meteorology; and some interesting earthquakes. The first three and last two chapters are shorter than the others. In addition, there are in the text eleven small line-diagrams, three large graphical diagrams, one map and an index.

Prof. K. E. Bullen, who is professor of applied mathematics in the University of Sydney and president of the Section of Seismology and Physics of the Interior of the Earth of the International Union of Geodesy and Geophysics in the present triennium, is a very brave man to try to get the whole of seismology into some forty thousand words, even though he limits the meaning of the word seismology and also freely employs mathematical symbolism including differential equations and triple integrals. His own researches have been largely concerned with travel-time tables and the determination of the numerical values of the physical constants of materials likely to be found at various great depths in the Earth. In this book he states the parts of the scientific method which he has used in his researches, gives the theoretical basis for his calculations, and summarizes the results so far obtained.

In fact, Prof. Bullen has dipped his 'spoon' of mathematics into the 'basin' of seismology, and mathematical physicists will be grateful for the 'taste' he offers them. Should they desire to go further, I would recommend them to begin with "Lectures on Seismometry", by Prince B. Galitzin, in addition to Prof. Bullen's larger book, "An Introduction to the Theory of Seismology" (second edition, 1953). ERNEST TILLOTSON

Collected Papers on Aviation Medicine

Presented at Aeronautical Panel Meetings of the Advisory Group for Aeronautical Research and Development, Palais de Chaillot, Paris. (AGARDograph No. 6.) Pp. vi+209+38 plates. (London: Butterworths Scientific Publications, 1955; published for A.G.A.R.D.) 37*s*. 6*d*.; 5 dollars.

EIGHTEEN different papers presented at various meetings of the Aeronautical Panel of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, are published in this volume. The selection of the various papers in no way covers the field of aviation medicine in systematic form. Instead, the reader is confronted with an unusually random choice of topics, the standard of which varies from the informal and superficial to the advanced and original academic paper one might expect to find in a specialist technical journal. This is due to the different aims of the meetings and also the function of the various authors. In this type of publication, therefore, there is an inherent diversity of approach and level of treatment, all the more apparent owing to lack of editorial supervision. Such criticisms, however, have sometimes been regarded as offset by refreshing variations in style, and in addition the book is very well illustrated. One cannot help feeling, however, that a more limited choice of papers could, with advantage, have been supplemented by the inclusion of discussion abstracts on the more controversial subjects.

Much of the progress of aviation medicine is concerned primarily with research in basic physiological and psychological problems, so that this type of publication should have its appeal to the specialists in these sciences also. A detailed paper by John P. Stapp covers his more important and original work on body tolerances to crash decelerations, and other topics include such subjects as a theoretical approach to cockpit layout, arctic survival, high-intensity noise and visual problems. Of particular interest is a short critical survey of present concepts relating to explosive decompression. Throughout, the reader is left in no doubt that aviation medicine research depends on a detailed application of electrometrical recording techniques, which are also introduced by a composite paper describing recent advances in this field.

F. LATHAM

PHYSIOLOGICAL CONTROL OF POPULATION GROWTH

By Sir SOLLY ZUCKERMAN, C.B., F.R.S.
University of Birmingham

THE heavy consumption of raw materials during the war years of 1939–45, and the phases of shortage that have punctuated the post-war period, have tended to encourage the belief that one day—in the words of the now-famous Paley Report of 1952*—the world will lack the material means to sustain its civilization. The emphasis of the discussion has now begun to shift. To-day we are being increasingly led to believe that modern technology can be relied upon to provide new resources in place of old: nuclear energy for coal; synthetic for natural fibres; and even factory-made food for the food that now grows in the fields. At the same time, however, we are hearing more about the raising of living standards in the under-developed countries, where the bulk of the world's population now lives and multiplies in abject poverty.

The present fear is not that the world's physical resources are in any immediate danger of exhaustion as such, but that plans for the economic growth of 'resource-needy' countries are going to be frustrated by the unrestrained growth of population. This view is the underlying theme of "World Population and Resources", a study recently issued by Political and Economic Planning (*Nature*, January 7, p. 5). It is given further point in the report of the October 1955 meeting of the Consultative Committee for the Colombo Plan (Cmd. 9622), which indicates that population is increasing in the Asian countries far more rapidly than new developments are creating new jobs; and the fear could not be better stated than it has been by the Economic Commission for Asia and the Far East (April 19, 1955) in the words: "despite the strenuous efforts made in the post-war years to increase output and raise levels of living, most countries of the region still found themselves, nearly a decade after the war, with *per capita* real incomes that were either lower than before the war, or barely at pre-war levels". Schemes of economic development may therefore well be nullified if the means are not found for adjusting both sides of the 'population-resources equation' in those 'over-populated' countries where the two are most out of balance.

In these circumstances it is highly encouraging that certain American organizations are making urgent efforts to focus attention on the need to study the problems that are involved in attempts to limit the growth of population. After some preliminary discussions between the Planned Parenthood Federation and the Committee on Reproduction of the National Research Council, the National Academy of Sciences in 1952 convened a meeting out of which emerged a new organization called the Population Council. This was set up with the support of Mr. John D. Rockefeller III; and the next step was the appointment of Dr. Warren O. Nelson, professor of anatomy in the State University of Iowa, as medical director of the Council, with offices in the Rockefeller Institute. Dr. Nelson has made it his business to become acquainted with all work, wherever it may be taking place, that bears on the problem of the control of fertility; and in October 1955 the Council assisted the International Planned Parenthood Federation to gather together at a meeting in Tokyo a number of economists, social workers and students of reproductive physiology. The result was an up-to-date assessment of the present position about the physiology of birth-control.

Reports about population and economic growth, given by the spokesmen of the resources-needy and impoverished countries of Asia, and of countries like Egypt, all struck the same note. Everywhere population was growing much more quickly than new resources were being created, and nowhere was there any adequate method of checking present rates of reproduction, which were high not because of any increase in fertility, but because of sharp declines in mortality-rates brought about by such events as the elimination of malaria following the discovery of DDT. In Japan the situation had become so serious that abortion had been legalized in an effort to reduce the strain of increasing numbers on an economy which has been struggling desperately to recover from the destruction of war.

The physiological papers dealt with possible means of checking or limiting the actual process of reproduction at one of its many stages, and were mainly concerned to show which lines of research held the greatest promise. In a general review, Dr. Nelson considered the various steps of the process, emphasizing particularly those which appear 'vulnerable', and therefore susceptible to 'designed interference'. For example, one of the more vulnerable stages of spermatogenesis is the meiotic division which primary spermatocytes undergo during the process of chromosomal reduction. The nitrofurans and related compounds can inhibit these changes; but their use in human subjects is contra-indicated because they produce undesirable side effects such as nausea and vomiting. Dr. Nelson's view was, therefore, that research along these lines is no more than "mildly encouraging". Such, too, was his general opinion of current efforts to use steroid hormones, and certain plant extracts (for example, species of the genus *Lithospermum*), to interfere with the action of gonadotrophic hormone.

Dr. S. N. Sanyal, of India, who announced some years ago that there was an anti-fertility substance in the legume *Pisum sativum*, presented a paper in which further claims were made for the anti-fertility properties of *m*-xylohydroquinone, the presumably active substance in the pea. Clinical trials were referred to; but the published results are difficult to assess. The results of animal experiments which Sanyal had reported earlier have not been fully corroborated by research workers either in Great Britain or the United States.

Work on plant extracts was also referred to by Dr. A. S. Parkes, of the National Institute for Medical Research, Great Britain, who in addition directed attention to earlier work on anti-gonadotrophins. Both he and Dr. M. C. Chang, of the Worcester Foundation for Experimental Biology, U.S.A., dealt with the part played in mammalian fertilization by hyaluronidase and hyaluronidase-inhibitors; but again the disappointing conclusion

* Resources for Freedom. In 4 volumes. (Washington, D.C.: Gov. Printing Office, 1952.)

was reached that there was no likely prospect that conception could be controlled by the systematic administration of an inhibitor which could inactivate spermatozoal hyaluronidase—an idea which was once thought to hold considerable promise.

New work on anti-gonadotrophins was reported by Dr. W. O. Maddock. When an animal is injected with gonadotrophins prepared from the tissues of another species, antibodies are formed which are not species specific, so that an animal so treated may become 'immune' to its own gonadotrophins. By proceeding along these lines, Dr. Maddock and his collaborators induced anti-hormone formation in a number of men and women who were receiving daily injections of sheep or hog follicle-stimulating hormone. One month after the cessation of injections, anti-hormone titres were at their maximum, and they usually remained at 'detectable levels' for 2–4 months. Spermatogenesis was apparently unaffected during the first month after treatment; but it was inhibited, as shown by a variety of tests, including testicular biopsies, during the second month. Corresponding signs of the suppression of endogenous gonadotrophin were also observed in the female patients, and in both males and females it was believed that the inhibitory effects of the anti-hormones were more pronounced during succeeding courses of treatment.

The expense, as well as the dependence on medical services of the procedures involved, scarcely encourage one to believe that methods of birth-control deriving from this approach are likely to have any general application in the greater part of the Asiatic world. The experimental results are, however, distinctly encouraging, and it is conceivable that they hold a key to the practical control of reproduction. Another physiological observation which may do the same was outlined by Dr. M. C. Shelesnyak, of the Weizmann Institute of Science in Israel. It has long been known that mechanical irritation of the endometrium during the luteal phase of the œstrous cycle will provoke the formation of decidual cells, and it has also been appreciated that this response can be related to the manner in which a placenta is formed when the endometrium reacts to the presence of an implanting blastocyst. Shelesnyak took as a working hypothesis the idea that a common factor, probably histamine, is always involved when a decidual reaction occurs. This hypothesis proved valid, and further experiment showed that 'histamine antagonists' inhibit the formation of deciduomata. It was then found that a single subcutaneous injection of ergotoxine will interrupt pregnancy in the rat. This physiological observation can be related to the well-established clinical fact that ergot may sometimes act as an abortifacient, although in circumstances which are not clearly understood.

The two communications which excited most attention dealt with the influence of progesterone and related compounds on ovulation, and with the abortifacient effects of a variety of substances described generally as 'anti-metabolites'. The clinical results of the first set of studies remain equivocal, although as Dr. Gregory Pincus, of the Worcester Foundation for Experimental Biology, pointed out, there is no doubt that progesterone can inhibit ovulation in rabbits and apparently, also, in rats. According to his own studies, the indications are that progesterone, when taken by mouth, will also inhibit ovulation in women, as determined by various indirect indices. This view was not, however, shared by Dr. Massomi Ishikawa, whose clinical trials had failed to provide any indication of the suppression of ovulation, though it was possible that the changes induced by the hormone in the cervical mucus might interfere with the penetration of sperm sufficiently to prevent fertilization, nor by Dr. A. Stone, of New York, who also reported on the negative effects of the oral administration of progesterone. These discouraging observations were, to some extent, counterbalanced by a few observations, also reported by Dr. Pincus, which suggest that 19-nor-17-ethinyl-testosterone and 17-ethinyl œstraeneolone may be more effective than progesterone in inhibiting ovulation.

The most dramatic story was that of Dr. J. B. Thiersch, of the University of Washington, who discussed the abortifacient action of certain anti-metabolites which are related to various aspects of nucleic acid metabolism, and some of which resemble in their molecular structure naturally-occurring compounds. The investigation began with the observation, made by chance during the course of work on the suppression of cancerous growth, that the folic-acid-antagonist 4-amino-PGA (aminopterin) will destroy the litters of mice, rats and dogs when given in the first trimester of pregnancy. Twelve anti-metabolites were then systematically studied, and nine were found to have a similar effect when given to rats on the seventh or eighth day of gestation. None was able to destroy the whole litter if given before implantation of the embryos, and no compound was effective when given late in gestation. When the drugs failed to destroy all the fœtuses, those young which survived usually developed abnormally, and were born in a malformed state. It was also observed that the placentas frequently survived even when the embryos were destroyed, and also that in certain cases the anti-metabolites had toxic effects upon the maternal organism (for example, on the bone-marrow). The most successful abortifacient in rats was azaserine, or azaserine given in combination with 6-mercaptopurine.

Aminopterin has now been given a clinical trial on twenty-six patients in whom pregnancy had to be terminated for medical reasons. The idea was that the anti-metabolite would be tried first, and in case of failure would be followed by operation. In the great majority of patients the drug acted as an effective abortifacient; but in the remainder there were complications (for example, either an abnormal fœtus was born, or it was necessary for the surgeon to intervene, in which case an abnormal fœtus was found; or general ill-effects occurred in the mother).

It was clear from this, as from all the other physiological papers of the conference, that the practical goal of these urgently needed researches—the discovery of a 'pill' which can be taken by mouth, and the only physiological effect of which would be that of inhibiting the development of the fertilized ovum, or of suppressing ovulation or gametogenesis at will—is so remote from realization that at this stage no one can say how, when or even whether success will ever be achieved. Other communications made it equally obvious that much study will have to be carried out in the field before it will be possible to say how different peoples are likely to react to efforts, officially sponsored or not, to spread a knowledge of birth control. The pressure of population on resources is being felt most acutely in those parts of the world which have never known anything but illiteracy, poverty, overcrowding and squalor. Experi-

ence has proved that Western methods of birth control can scarcely be used in such conditions. Moreover, however much some of the people concerned would like to have small families, most of them are either too ignorant or too resigned even to take the trouble to understand the simple facts that are involved in human reproduction. Great efforts have been made in a few areas to overcome these obstacles; but so far with results that are trivial in relation to the size of the problem.

The situation would obviously be transformed if the 'pill' were ever discovered. But the 'pill' would need to be essentially 100 per cent certain, and commercialization would have to be resisted until the most rigorous clinical trials had been carried out, and until it had been shown that there was no danger of any long-term deleterious effects. The Asian peoples are not provided with lavish medical services, and it would be unthinkable to encourage the use of a drug which was not virtually certain in its action, if its failure meant that a medical man would have to be called in. Moreover, if the drug only affected germ cells or an embryo deleteriously, without destroying them fully, the results could be even more disastrous to the future than the unrestrained growth of population. The West will, therefore, be hurting, not helping, the underdeveloped areas of the world, and would be doing irremediable harm to the good name of Western physiological science, if a 'pill' were launched upon the world before its capacity to satisfy all the desiderata, scientific and social, had been established. But the West will be doing nothing but good if it continues to press on with the kind of physiological research of which the Tokyo meeting provided so useful a résumé.

THE SCIENTIFIC WORK OF BENJAMIN FRANKLIN

By Prof. E. N. da C. ANDRADE, F.R.S.

IN 1746 Benjamin Franklin received from Peter Collinson, of London, a glass tube suitable for carrying out experiments on frictional electricity, with directions as to how to use it*. He set to work on the subject with enthusiasm, writing "For my own part, I never was before engaged in any study that so totally engrossed my attention and my time as this has lately done". He was thus forty years of age (having been born on January 17, N.S., 1706) when he first took up the subject which was to make his name immortal in the world of science, and for seven full years thereafter he was engaged in pioneering experiment, shrewd deduction and simple but penetrating theory. The results of his electrical researches were communicated in a series of letters, beginning in 1747, to Collinson, who was a Fellow of the Royal Society. The publication of these letters as a book in 1751 made Franklin famous throughout Europe and two supplements were issued, the last in 1754. In 1757 Franklin came to England as official representative of the American Colonies, and after that date, although he continued to take a lively, stimulating and practical interest in scientific matters, the pressure of his public duties as a negotiator and statesman made the systematic pursuit of experiment impossible.

One of Franklin's earliest observations, of which he made full use, was on the power of a metal point to discharge an electrified conductor, in his case a large shot insulated by being placed on a clean, dry glass bottle. He generously acknowledged that the first experiment was made by his friend Hopkinson, who, apparently, did nothing to follow it up. If a pointed bodkin was attached to the shot it rapidly lost its charge, as it also did if the bodkin, earthed by being held in the hand, was presented, even at a distance of 8 in., to the shot. If the bodkin was insulated, no such effect took place. He later carried out a similar experiment with a very large charged cylinder made of pasteboard covered with metal foil, when he showed that an insulated man, presenting the point of a needle, became charged. Franklin likewise observed the glow at the point that accompanied the discharge. He put forward an explanation of the discharge from a pointed conductor in terms of the attractive force by which the charged body retained its electrified atmosphere: at a point there was a very small attractive surface and a relative inability to hold the charge. These experiments were to lead to the lightning rod.

Very early Franklin carried out experiments in which a man on an insulating base (a block of wax) electrified a glass tube by rubbing and then communicated a charge to another man similarly insulated. By variations of circumstance, including an earth provided by a man standing on the floor, he came to the sound conclusion that, as he put it, electricity was not created by friction, but collected —that there was a separation of electricity which left behind it a corresponding defect. In consequence, he introduced the terms 'positive' and 'negative' electricity, as still used, the electricity of the rubbed glass being positive. His theory was therefore called the 'one-fluid theory'. He also brought into regular use the terms 'non-conductor' and 'conductor' (the term 'conductor' had already been used by Desaguliers) in place of 'electric per se' and 'non-electric' then in general use.

His work on the Leyden jar, which had been discovered in a primitive form by von Kleist in 1745 but brought into general notice by Musschenbroek, of Leyden, in the following year, added clarity to what was a very obscure subject. He showed that the two coatings were oppositely charged and, in particular, that one coating had to be earthed while the other was electrified. He showed the large part played by the glass in the action—in fact, he declared that the whole power of the jar to give a shock lay in the glass. The correct elucidation of the action of the dielectric had to wait for Faraday. While carrying out this work, he simplified the whole matter by making the first plane condenser, of sheets of glass between plates of lead, the so-called Franklin panes, which enabled the coatings and the glass to be readily separated and conjoined. (Franklin has a note to his Letter IV, of 1748, "I have since heard that Mr. Smeaton was the first who made use of panes of glass for this purpose", but I have been unable to trace any record of this work of Smeaton's.)

* With regard to an erroneous date given in Franklin's "Autobiography" and to the general history of Franklin's introduction to the study of electricity, which has been somewhat obscure, see Heathcote, N. H. de V., *Isis*, **46**, 29 (1955).

It was, of course, Franklin's work on lightning and the lightning-rod that was chiefly responsible for his scientific fame. He was not the first to direct attention to the resemblance of the light and sound of the electric spark to lightning and thunder. Hauksbee (1705), Wall (1708), Newton (1716) and Gray (1735) had all referred to it casually, the last-named saying, for example, "that power [electricity] which by several experiments . . . seems to be of the same nature with that of thunder and lightning". It was, however, left to Franklin to show systematically that there was something more than a superficial resemblance, that thunder clouds were actually seats of electric charge which could be shown to behave like normal charges and that the action of pointed conductors, which he had so thoroughly investigated, might be used to dissipate the charge or, if this action was insignificant, to attract the lightning discharge and carry it harmlessly to earth, so as to protect buildings. He proposed what is known as the Philadelphia experiment: that a sentry box should be placed on a high building, with a long pointed rod, well insulated, protruding upwards. He anticipated that, when thunder clouds were overhead, a man in the box would be able to draw sparks from the rod by presenting to it an earthed wire, held by an insulating handle. The experiment was first carried out in France, in May 1752, by D'Alibard at Marly and by Delor in Paris independently. It met with a full success, which created a sensation, Delor obtaining sparks nearly an inch long.

It was later that Franklin carried out the famous kite experiment, described in a letter dated October 19, 1752. The lower end of the string of the kite, which became conducting when wet, was attached to a silk ribbon, which insulated it from the hand. Sparks were obtained, a Leyden jar charged and other standard electrical experiments performed. Among the last experiments made by Franklin were some on the sign of the charge on thunder clouds, which he found to be in most cases negative, although occasionally positive charges occurred, which modern observation has confirmed.

Of Franklin's design of lightning rod, pointed above and earthed below, it will suffice here to quote the modern lightning expert Dr. B. F. J. Schonland: "Franklin's specifications for the rod . . . have proved substantially correct".

Other effects of atmospheric electricity were also studied by Franklin. He recognized the aurora borealis for a phenomenon of electric discharge. He stated that the atmosphere at above a certain height was so rare as to be almost a vacuum and therefore a good conductor of electricity. The discharge he supposed caused by electrified vapours rising from the sea and proceeding to the pole, where the non-conducting nature of the ice played a part—an explanation on scientific lines at a time when greater correctness could not be expected. He may be said to have foreseen the ionosphere: "Who knows but there may be, as the Antients thought, a region of this fire [the electric 'fire'] above our atmosphere, prevented by our air, and its own too great distance for attraction, from joining our earth?".

While it was for his experiments on electricity that Franklin was best known, these constitute by no means his only claims to consideration as a man of science. Among meteorological phenomena he was much interested in whirlwinds and waterspouts, which he recognized as due to the same cause, a very rapid local circulation of the air, with a consequent region of low pressure in the neighbourhood of the axis. He thought, however, that the waterspout consisted of water, whereas it is a cloud of water drops and droplets, and so was puzzled by the height, for he clearly recognized that the atmospheric pressure could not hold up a volume of water more than 30 ft. in height.

There are a host of original observations to be found in Franklin's collected papers. He makes the generalization that good conductors of heat are good conductors of electricity, long before the days of voltaic electricity. He explains that clothes keep the body warm by retaining and confining the natural heat, wool being warmer than cotton because it is a much poorer conductor. He has some penetrating remarks on the cooling produced by evaporation, from which he proceeds to explain the beneficial effects of perspiration in keeping down the body temperature in hot weather.

Everywhere his acuteness is evident. For example, he was, after looking closely into the matter, strongly in favour of inoculation against smallpox; but, after systematic trial, considered that electric shock from the discharge of a Leyden jar was of no use as a cure for paralysis and such-like ills, saying that he had never known any advantage that was permanent. This was at a time when John Wesley was writing of the most extraordinary cures, even of blindness, produced by electric shocks and when Priestley wrote that "electricity is now become a considerable article in the *materia medica*".

As an inventor Franklin is best known for his stove, his 'Pennsylvanian Fire-Place'. He pointed out that with the fireplaces then in use the hot air passed up the chimney, its place being taken by air coming as a violent draught through crevices, which was a great promoter of the common cold. In Franklin's invention the stove stood a foot or so in front of the wall. From the front part where the fire was burning the hot air within the stove rose to strike a horizontal plate and was then led down a pipe of rectangular cross-section, which enclosed a so-called air-box between itself and the fireplace proper. This pipe entered the chimney at floor level. The hot air thus heated the whole stove and, in particular, the sides of the air box, as well as the wall. The fresh air was supplied through a pipe under the floor. In pointing out the saving of fuel and the absence of violent draught Franklin, ever a man of sense and of the senses, directed attention to the fact that one did not lose the pleasant sight of the fire and could also use the flat top to warm flat irons or keep food warm. Among his other inventions the most familiar to-day is that of bifocal spectacles.

It may be fitting to conclude these very brief notes on Franklin's scientific work with words that appear to be little known, though spoken by one of England's greatest natural philosophers, Sir Humphry Davy. They cannot well be bettered. "The experiments adduced by Dr. Franklin in support of his hypothesis were most ingeniously contrived and happily executed. A singular felicity of induction guided all his researches, and by very small means he established very grand truths. The style and manner of his publication are almost as worthy of admiration as the doctrines it contains. He has endeavoured to remove all mystery and obscurity from the subject; he has written equally for the uninitiated and for the philosopher; and he has rendered his details amusing as well as perspicuous—elegant as well as simple".

STATISTICS AND AERODYNAMICS OF THE SEA SURFACE

THE importance of physical oceanography to meteorology arises partly because of similarities in the circulation patterns in the atmosphere and in the ocean and partly through the exchange processes at the shared boundary between them. The atmosphere is thermally driven, the ocean in part thermally but mainly by the frictional drag of the wind. The similarity of their circulation patterns, which exists in spite of their different boundaries, is presumably due to the rotation of the Earth. No realistic theory of the general circulation of either the atmosphere or the ocean is, however, possible without an extension of our knowledge of the transfer of heat, water vapour and momentum at the sea surface.

With this in mind, the Council of the Royal Meteorological Society recently invited papers on physical oceanography for publication in its *Quarterly Journal*. Several such papers have now appeared, and the Society organized two symposia on oceanographic subjects. The first, a joint meeting with the Challenger Society, was held in London on June 15, and the second formed part of the Society's summer meeting, held during July 22–23 at Ashburne Hall, University of Manchester. At both symposia the main topic was the statistics and aerodynamics of the sea surface.

The mechanism by which water waves are initially generated by wind is not yet understood. Distinct from this is a wide variety of problems, ranging from the reflexion and refraction of electromagnetic radiation to the motion of ships, the solution of which needs an adequate description of the statistical structure of the sea surface. One mathematical model which has recently been found to give realistic results is obtained by regarding a physical quantity, such as the height of the sea surface at a given point, as the resultant of a spectrum containing a large number of sinusoidal components of differing frequency the phases of which are uncorrelated. Such a model has been intensively studied by Rice[1] as a description of the statistics of random-noise currents in electronic devices. The word 'random' here implies the mathematical model already mentioned and is often replaced by the word 'gaussian', since on this model instantaneous amplitudes have a gaussian distribution. Many of Rice's results can be directly applied to the statistics of sea waves, for example, the change of height of the sea surface observed at a single point; they are being extended by Longuet-Higgins and others to take account of the movement of sea waves in different directions.

At the joint meeting of the Royal Meteorological Society and the Challenger Society in June, Dr. M. S. Longuet-Higgins gave an account of his paper[2] in which he discussed the distribution of wave heights, measured from crest to preceding or succeeding trough, for the case of a narrow spectrum. In this case the result is the well-known Rayleigh distribution, which has been found to agree closely with observation by several workers, including Commander C. R. Darlington[3], who has recently analysed waves automatically recorded by ingenious apparatus in an ocean weather ship. The good agreement exists in part because the wave records examined have been made by equipment which attenuates components of higher frequency, so that the spectrum is artificially narrowed. Rice has also derived an expression for the statistical distribution of maxima in gaussian noise with an arbitrary energy spectrum. The expression is complicated, but depends on a single parameter which can be derived from the energy spectrum or otherwise; it is applicable to a wide range of geophysical variations. Mr. D. E. Cartwright described his application of the formula to the distribution of the maxima in records of ship motions and ocean waves, the maxima now being measured from the zero line and not, as in Dr. Longuet-Higgins's paper, from an adjacent minimum. The theoretical distribution is in good agreement with those observed for energy spectra of different shape. It is clear from Mr. Cartwright's paper that the mathematical model of gaussian noise, and any extension to it, will be useful in the interpretation of many geophysical time-series, particularly records of ocean waves, and may well suggest physical ideas about the mechanisms which are involved.

From the statistics of the sea surface the meeting then turned to its aerodynamics. One of the most important problems common to oceanography and meteorology concerns the mechanism by which momentum is transferred to the sea surface. The drag and some of the statistics of the sea surface must be closely related; but, since as yet it is not clear which of the statistics are relevant, both statistics and drag are usually discussed in relation to the wind at a known height. The remainder of the meeting was devoted to observational estimates of the drag of the wind on the sea, expressed in terms of the stress coefficient C defined by the equation $\tau_0 \equiv C\rho u^2$, where τ_0 is the surface shearing stress, ρ the density of the air, and u the wind speed at a known height, usually about 10 m. above the surface.

Mr. J. S. Hay read his paper on air flow over the sea[4]. He had measured the vertical distribution of wind velocity to a height of 8 m., from a large raft moored some 800 m. downwind of a Hebridean island. In neutral and unstable conditions, the wind increased linearly with the logarithm of the height; but when the sea was colder than the air, the profiles were slightly curved, being convex to the log z axis. Wind profiles over land in neutral conditions are well known to be represented by

$$u/u_* = (1/k)\log(z/z_0) \qquad (1)$$

where u is the velocity at height z, u_* is the friction velocity defined by $\tau_0 \equiv \rho u_*^2$, k is von Kármán's constant ($= 0{\cdot}4$) and z_0 is a length known as the roughness parameter which is thought to be determined by the statistics of the surface. Making the very reasonable assumption that wind profiles over the sea can be expressed by the same equation, Mr. Hay determined C and z_0 from his observed profiles. Both C and z_0 varied approximately linearly over the range of wind speed of 650–1,150 cm./sec. at 10 m., the former from 0·0016 to 0·0024 and the latter from 0·05 to 0·25 cm. Uncertainties introduced by possible errors in the height of the anemometers were estimated and found to have little effect. Others, such as those due to the platform and to tidal streams, could not be assessed, but the profiles were considered typical of the sea surface in spite of a cliff 60–90 m. high about 1 km. upwind.

Dr. H. U. Roll, a guest of the Society from Hamburg, then gave an account of an investigation he had made[5] by comparing Beaufort force estimates of wind at sea, apparently based on the appearance of the sea surface, with the measured wind in relation to the temperature difference between sea and air. In spite of the experimental scatter, it was clear that for a given Beaufort force the wind was stronger in stable conditions than in unstable conditions. He had also found that the estimates of Beaufort force were linearly proportional to the wind speed 50 cm. above the surface and, by combining the two results, had made estimates of the drag coefficient in neutral, stable and unstable conditions. In neutral conditions, he found that the drag coefficient increased roughly linearly from 0·0008 to 0·002 as the wind at 19 m. varied from 2 to 15 m./sec. Dr. Roll considered these values were in fair agreement with what he thought were the most reasonable earlier estimates, although there was some evidence that at low wind speeds the drag coefficient increased as the wind speed decreased.

After some interesting observations by Dr. H. Arakawa on the complicated wave trains produced by fast-moving typhoons, Mr. J. Darbyshire gave an account of estimates[6] of drag coefficient made by an old method, that of observing the tilt to leeward of an enclosed body of water under the influence of wind. The slope of the surface of Lough Neagh in Northern Ireland had been determined from continuous records of water-level at four points near the shore, and the corresponding winds were taken from anemometer records at Aldergrove nearby. The experimental scatter was such that the variation of drag coefficient with wind speed could not be determined; there was some indication that the drag increased as the wind speed was raised to a power between two and three. Stability appeared to have a marked effect, the drag coefficient for moderate instability being about twice that for moderate stability. The drag coefficient also appeared to vary linearly with the distance between the observing points, indicating a possible effect of fetch. This is an important point which has not been brought out in previous investigations; it deserves further investigation.

It was clear from this joint meeting of the Challenger Society and the Royal Meteorological Society, and from the discussion which followed, that experimental determination of wind stress by any known method is a matter of some difficulty, so that estimates made by different workers are significantly different. Nevertheless, there is a growing belief that the drag increases with velocity rather more quickly than u^2 but slower than u^3. At the summer meeting of the Royal Meteorological Society at Ashburne Hall, two attempts were made to deduce the variation with wind speed, but both were necessarily hypothetical and tentative.

The first[7], by Prof. W. H. Munk, was based on various assumptions, one being that the drag due to skin friction can be linearly added to that of form drag against the waves to give the total drag. The remainder of the paper is concerned with the estimate of form drag, using an extension to Jeffreys's sheltering theory to cover the case when there is a spectrum of waves and not a simple sinusoidal wave-train. It turns out that the relevant statistic is the mean-square slope. Cox and Munk[8] have recently estimated the mean-square slope from photographs of the sun's glitter on the sea surface and find that it varies linearly with wind speed. The overall result is then that the form drag varies as the wind speed cubed. If the drag due to skin friction, approximately proportional to wind speed squared, is added, then the total drag varies with wind velocity in the expected way. Further, since the drag is associated with the slopes of the waves rather than with their heights, the effect of fetch would be expected to be small. Prof. Munk's paper could be, and was, criticized on many points of detail, but there was general admiration for this new and deductive attempt to clarify a major problem—the relation between real and aerodynamic roughness—which has not been resolved even for the simpler case of solid surfaces.

Munk's treatment is in terms of the wind speed at 'anemometer' height, but he is well aware that the variation of wind with height is an important factor, the aerodynamic roughness usually being defined from the wind profile. Wind profiles over water have been investigated by Mr. H. Charnock, whose paper supplemented that of Munk and was read immediately after it. From careful measurements over a large reservoir, he found that the wind speed varies linearly with the logarithm of the height as in equation (1). To characterize the profiles, their slope u_*/k is plotted against their intercept $\log z_0$. This allows a direct comparison with other profiles, including those measured in the laboratory. The agreement is better than expected, and it is surmised that z_0 is comparatively independent of fetch and stability, but is determined largely by u_*. The relation between u_* and z_0 agrees roughly with the simplest non-dimensional relation between them, $u_*^3 = \text{constant} \times z_0$, so that one is led to a generalized wind profile for flow over a water surface:

$$u/u_* = (1/k)\log(gz/u_*^2) + \text{constant},$$

which specifies the drag, given the wind at one known height, the constant being approximately 12·5. This expression is in rough agreement with earlier work but the experimental scatter is large.

These two papers attempted to deal with the same problem from completely different points of view. The conclusions agreed to some extent and pointed to the need for more precise observations. Dr. Longuet-Higgins described an attempt to measure the form drag of the larger waves by making detailed recordings of pressure at the sea surface. The equipment, constructed at the National Institute of Oceanography, consists of a flat circular buoy about 6 ft. in diameter and arranged to float low in the water. Inside are two gyroscopes to record pitch and roll, a vertical accelerometer from which vertical displacements can be obtained, and a sensitive micromanometer to record small variations in air pressure. Successful recordings have already been made at sea and are being analysed.

Other discussion ranged over a wide field and showed the common interest of meteorologists and oceanographers in problems of the sea surface. Judging from these meetings, the Council of the Royal Meteorological Society has no cause to regret its decision to regard physical oceanography as a reasonable extension of its sphere of interest.

H. CHARNOCK

[1] *Bell Syst. Tech. J.*, **23**, 282 (1944); **24**, 46 (1945).
[2] *J. Mar. Res.*, **9**, 245 (1952).
[3] *Quart. J.R. Met. Soc.*, **80**, 619 (1954).
[4] *Quart. J.R. Met. Soc.*, **81**, 307 (1955).
[5] *Ann. Met. Hamburg*, **6**, 257 (1953/4).
[6] *Quart. J.R. Met. Soc.*, **81**, 333 (1955).
[7] *Quart. J.R. Met. Soc.*, **81**, 320 (1955).
[8] *J. Mar. Res.*, **13**, 198 (1954).

FRUIT AND SEED PRODUCTION*

By Sir EDWARD SALISBURY, C.B.E., F.R.S.
Director, Royal Botanic Gardens, Kew

EVERYONE who owns a garden in which fruit is grown soon becomes aware that the crops of plums and apples are liable to great fluctuations. For these fluctuations the weather is popularly blamed, but is in fact only in part responsible. In so far as we can blame the vicissitudes of our climate, it is important to remember that the flower rudiments, which must be formed for fruit to eventuate, are laid down ten or eleven months before the fruit tree produces flowers. So that the failure of a fruit crop as affected by weather may be due to conditions operating at any one of the critical phases in flower and fruit development, either directly, or indirectly as by affecting the growth hormones. For example, it may be the effect of frost when the flower initials are laid down in June, it may be cold winds at pollination time that prevent the bees visiting the flowers, or late frosts that check the growth of the germinating pollen and inhibit fertilization. But, in addition to these hazards of nurture extending over a period of more than a year, there are inherent idiosyncracies of the kind of plant with which we are concerned.

Some plants only fruit once in their life-time—a characteristic that we are apt to assume is inevitable for the annual. But in fact some annuals, if most of their flower buds be removed, will not only survive from year to year but also can be permitted each season to set a limited amount of seed. Moreover, the fruiting period of annuals varies greatly in length. In many this is quite brief, while in others, such as some strains of the chickweed, flowering and fruiting may extend over months. In a biennial such as the mullein (*Verbascum thapsus*) there is a period of accumulation by the rosette stage during one season, followed by fulfilment in the second, and here again prevention of flowering and fruit formation can prolong the life of the plant. There are, however, a number of unquestioned perennials which only fruit once in a life-time and then die. A classical example is the talipot palm (*Corypha umbraculifera*) that remains in the vegetative state for about forty years, and then all its accumulations of food are spent in one magnificent display of flower and a prodigious production of fruit. Similarly, some bamboos in India exhibit prolonged vegetative growth and then simultaneously flower and fruit over an extensive range of country, with important economic and social consequences.

All these and other such examples might seem to suggest that food accumulation and its depletion were the primary factors, and that all are mere variations on the same theme, since most trees and shrubs have to attain a certain maturity before they produce fruit.

It has been shown by numerous experiments on a variety of plants that the initiation of flower rudiments is greatly influenced by the relative length of daylight and darkness, which may thus not only regulate the seasonal flowering of a species but also its geographical range. It must, however, be emphasized that though photoperiodic stimulation and temperature are clearly important external factors in determining flower initiation and subsequent development, yet for these to operate a certain internal environment is requisite which Klebs termed "ripeness to flower", and the ratio of carbohydrates to mineral nutrients, although not causal as at one time supposed, is probably an important aspect of these internal conditions.

When I was a child the commonly cultivated *Cosmos* was a markedly short-day plant, so much so that it was only stimulated to form flowers so late in the season that the plants would attain a height of six or seven feet and get cut down by frost before the flower-heads opened. The common annual mercury, on the other hand, is indifferent to day-length, but its time of flowering was shown by M. Troupin to be greatly influenced by the temperature at night. If this were high, flower-buds might be formed twelve days after germination, whereas with low night temperatures these might not appear for four weeks.

Nevertheless, the variation in time that elapses before sexual maturity is often a characteristic of the species or variety. Particular interest is attached to the fact that scions obtained from the same individual apple variety grafted on to one type of root-stock always come into bearing early; grafted on another type of root-stock they fruit some years later. Thus it is the vegetative part of the dual organism presented by the grafted apple tree, and not the reproductive partner, that mainly determines the period of fruition.

But whatever root system upon which we graft, we see evidence of the individuality of the reproductive portion from the fact that certain apple varieties such as Ribstone Pippin tend to bear crops every year, whereas many other varieties, such as Blenheim Orange, normally fruit appreciably in alternate years only. The forester also is familiar with the periodic fruiting of oaks and beech trees, which exhibit mast years at intervals, the regularity of which is mainly influenced by climatic conditions. These may shorten or lengthen the interval between heavy crops, but not sufficiently to obscure the general periodic character of their occurrence.

Many trees that occur as natural dominants appear to exhibit periodicity in some degree; and it may well be that this, as I have suggested for herbaceous species of intermittent habitats, has a definite survival value in tending to evade the build-up of large populations of pests and predators. Copious intermittent seed production and seedling populations might thus have marked advantages over the steady annual output at a lower level of fruitfulness.

What determines periodic fruitfulness still remains to be determined; but the fact that drastic thinning of apples early in the year of marked fruitfulness, or prior removal of fruiting spurs, only in part overcomes the biennial fruiting habit, suggests that accumulation and exhaustion of food reserves is but one aspect of a complex problem.

Apart from the more striking intermittences of fruitfulness, there is, in temperate climes at least, a periodicity imposed by the seasons. Quite commonly

* Substance of a Friday Evening Discourse delivered at the Royal Institution, London, on October 28.

the seasonal production of seed does not coincide with the conditions favourable for germination, and when these recur the advent of temperature and moisture conditions that would induce germination may occur at times unfavourable to survival.

We now know that many seed coats contain water-soluble substances that tend to inhibit germination until removed. Thus seeds of succulent fruits, despite the access of moisture and warmth, remain dormant until after the seed is shed. In very wet seasons these inhibitors may become washed out so that the seeds germinate precociously, and the apparent inconsistence of an inhibitor is realized, in fact, as an asset that, like the dormancy imposed by many seed coats, owing to their impermeability until they have undergone some measure of decay, is in reality a feature which confers a degree of temporal distribution on seedling production that is an insurance against catastrophic elimination.

The seed has a resistance to extreme conditions and a capacity for survival of adverse circumstances far surpassing that of the plant itself. Seeds have been known to survive the temperature of liquid air and that of boiling water. Moreover, the evidence of the seeds of the lotus (*Nelumbium speciosum*) from the Manchurian peat indicates a capacity for the retention of viability for perhaps a millennium. The annual plant has become a marked feature of the desert, where the adverse season is evaded by the resistant seed phase. Further, the abbreviated span of life that many annuals have assumed has not only fitted them for areas with short growing seasons due to natural causes, but also for the artificially limited growing seasons imposed by man's cultural operations. This short life-history of but a few weeks can, under more continuing favourable conditions, be translated into a succession of life-cycles so that if all the offspring of each generation were to survive, the total population at the end of one year would be numbered in thousands of millions. Thus by sheer pressure of potential offspring their successional frequency is well-nigh assured, and many such have become notable weeds.

If a high seed production be one important factor favouring success, and studies carried out on a large number of British species warrant this conclusion, it is nevertheless clear that for a given capacity for food manufacture, determined in large measure by the total leaf surface of the plant and the environmental conditions in which it is situated, the number of seeds produced must in some considerable degree be inversely related to the seed size.

The size of the seeds of one and the same species does not usually exhibit any great variability. Indeed, the grain of primitive wheats was, as we know, a measure of weight to which the nomenclature of the curiously antiquated system of Britain still bears witness. But variation in seed size is by no means negligible in some species, and this has an important bearing on dispersal as it affects competition.

When we consider the diversity in size of individual seeds of different kinds of plants, the range is astonishingly large. On one hand we have the minute seeds of many epiphytic orchids and parasitic plants that are dust-like and of which more than thirty-five million would be required to weigh an ounce. At the other extreme there is the double coconut (*Lodoicea sechellarum*), the single-seeded fruit of which may weigh 40 lb. It is not surprising that the palm which produces these prodigious fruits does not start fruiting until it is 20–30 years old, and that each fruit takes about a decade to mature. The baby palm after the seed has germinated is not weaned from its bottle for several years, but such is the plentitude of food provided for the young plant that apart from any catastrophe its establishment is almost assured. But such a large fruit can only be dispersed by water, and its very restricted distribution bears witness to the fact that it suffers from the defects of its virtues, as is also shown by records of seedlings that have perished from the burden of their inheritance when stranded with the plumule underneath.

Some years ago, from an extensive study of the seeds of British plants, I was able to establish the fact that there was a marked association between seed size and the natural habitat conditions of the species concerned.

The more advanced the type of plant community of which the species was a normal colonizer, the heavier the seed or fruit tended to be. The more open the vegetation and the less shaded the habitat the smaller would appear to be possible the seed size without detriment to survival. Put in other terms, this seems completely plausible, since the more closed and shaded the community of plants the larger the food reserve requisite to enable the seedling to raise its foliage into a position where it can obtain the essential illumination.

It is undoubtedly true that genetical factors govern seed size and that, in general, related plants tend to possess seeds of similar dimensions. Most members of the Onagraceae, for example, have very small seeds like the willowherbs. The fuchsias, which are largely plants of the forest margins of South America, have seeds that are not much larger, though the enchanter's nightshade (*Circaea*) has quite sizable one-seeded fruits and is a shade plant. Since certain families are often associated with particular types of habitat, it might be thought that any kind of relation between seed size and situation was purely fortuitous. Comparison, however, of the seeds of species belonging to the same genus but occupying differing types of habitat does reveal that the same relation generally obtains, namely, of the smaller seed with the more open type of community.

It is not without significance that many of the most striking of the apparent exceptions are plants which, because of their special modes of nutrition, are to a greater or less extent immune from the effects of shading. Thus, saprophytic and parasitic plants in general, even those of deep shade, have normally minute seeds. An exception among the parasites is the toothwort (*Lathraea squamaria*), which is definitely a shade species, but as it is parasitic on the hazel, lime and wych elm it may well be that the larger food reserve is requisite for the seedling to penetrate to sufficient depth to establish contact with the roots of the host plant. Nearly all orchids, whether saprophytic or not, have minute seeds ; but many, and perhaps most of these, are largely if not wholly saprophytic in the early stages of development, and the seedlings are notoriously tolerant of shade.

Some idea as to the small size of orchid seeds can be gained from considering those of the sweet-scented orchids of the chalk downs of Britain, of which it would require more than fifty million to weigh one pound. The seeds of the parasitic broomrapes are not quite so light ; but an ounce of these would represent about a million and a half seeds.

Seed size then, I suggest, is to be regarded as mainly determined by the average requirements for estab-

lishment. The larger the food supply provided by the parent the better, so long as this does not conflict with other assets of survival value, of which the necessity for dispersal to diminish competition between the offspring and with the parent is one, and number of seeds produced is another. Natural selection has imposed a compromise between these conflicting requirements. It is in the light of such a concept that we must consider fruit and seed production.

It is manifest that species of open habitats, particularly those which are pioneers on bare soil, are in the best position to dispense with a large food reserve, and they are also those which can most benefit from a large seed output because such habitats offer ample colonizing space. It is, in fact, among such that the smaller seeds and the larger outputs are to be encountered; but, apart from the special nutritional classes already referred to, the maximum outputs appear to be associated with what I have termed the species of intermittent habitats—those environments such as woodland clearings or bare mud exposed during periods of drought which offer, periodically, habitats for the opportunists of the vegetable kingdom. In the woodland the foxglove and the mullein are examples, while on the mud we might cite *Chenopodium rubrum* and *Veronica anagallis*. The individual fruits of the foxglove usually contain more than a thousand seeds, there being normally more than eighty capsules on one plant, and the average seed output of a plant is more than 85,000. The largest specimens, however, may produce well over a million seeds. The stupendous populations that are sometimes encountered on areas of felled woodland are in marked contrast to the few individuals that are to be found at the woodland margins during the intervening period. So, too, the mullein (*Verbascum thapsus*) produces more than 226 capsules, each containing about six hundred seeds; the average output is therefore about 136,000 seeds, and the largest specimens I have seen must have produced more than 1,200,000 seeds. A single pod of a vanilla orchid was estimated to contain some sixty thousand seeds, and a single plant may produce more than thirty such, or some two million seeds.

The red orache (*Chenopodium rubrum*) is often seen on manure heaps and rich garden soil; but, as a really wild plant, it is a feature of the exposed mud of ponds and reservoirs, where almost pure stands sometimes occur, developed from seeds dormant in the mud for many years, and a rough estimate of the productiveness of such plants was well over 250,000.

It is worth noting that what has been described as the smallest British flowering plant, the chaffweed (*Centunculus minimus*), grows on exposed mud, and having regard to the very small leaf area it presents its output is remarkable, namely, an average of 245 seeds, but these, needless to state, are very small, weighing only about 0·00003 gm.

Herbert Spencer believed, and the view was widely accepted, that seed output of a plant was proportional to the risks of its survival. It is obvious that such risks must be covered by an adequate insurance, and the comparative stability of plant populations over long periods might lend colour to this view. But that it is entirely misleading is obvious from the fact that those species which would be expected to take out the highest premiums in the form of a large output have taken out a low one. Indeed, it is usually the rarest species and those which demand the most specialized conditions that have the smallest seed production, while it is the commonest and most widespread that form large numbers of seed. The common pink centuary (*Centaurium umbellatum*), so widespread on the chalk downs of Britain and in woodland rides, has an average production of about eleven thousand seeds, whereas the local *Centaureum littorale* produces an average of approximately two thousand. The water plantain (*Alisma plantage*), that is to be found in almost any shallow pond, averages some thirty-six thousand, whereas the rare and local starwort (*Damasonium alisma*) produces a meagre 230, of which perhaps not more than one-quarter are viable.

It is probable that one of the reasons why many species are rare is because they are unable to exert sufficient population pressure. That they are able to survive despite the low premium they pay in seed output may well be in part due to greater precision in dispersal as, for example, by birds that frequent the particular type of habitat that they and the plant share. Moreover, it is generally true that the more specialized the habitat conditions the fewer the number of species associated with them. If we think of plants for our present purpose as belonging to two categories, namely, the specialists and the general practitioners, the former at the sacrifice of a more limited range of possible habitats are likely to be confronted with a smaller range of competitors and perhaps fewer of them. Thus the probability of similar demands in time and space from their associates are appreciably lessened.

It follows from what has been said that, in general, trees will possess the heaviest seeds because so many of them are natural inhabitants of shady places, and in the British flora the trees with light fruits, such as the birch, the pine and the ash, are colonizers of the open and pioneers, while the trees of the closed woodland, such as the oak and the beech, have fruits with appreciable food reserves. In the tropics, however, many tree fruits are very large. The double coconut is a shade species of palm, while the fruits of *Caryota mitis*, a palm which grows in open situations, are comparatively small. We are all familiar, too, with the large stones of the avocado pear and the mango, both of which are shade trees. The seeds of *Paulownia*, one of the few scrophulariaceous trees, are small, like those of other members of the family. Again, jungle climbers may have very large seeds, and in this connexion the genus *Entada* is of interest as illustrating effective water dispersal which obviates one disadvantage accruing to large seeds. Some few years ago, when staying with the Van der Byles at Caledon, Cape Colony, Lord de Saumarez came in to dinner bringing with him to show me two seeds that he had picked up on Cape Agulhas, the southernmost point of the African continent. One was *Entada scandens* and the other *Entada gigas*, the latter a native of the West African forests and the former of the forests of the Amazon valley. From the distribution of the ocean currents it is probable that the large seeds of the *Entada gigas* were washed into the sea off the West African coast, carried across the southern Atlantic towards the mouth of the Amazon, and thence carried back in company with its congener, *Entada scandens*, to the beach at Cape Agulhas. Seeds of *E. scandens* often reach the coast of Cornwall and have been found to be viable, and I have little doubt that these from South Africa were also. Similarly, the dangerously hooked fruits of *Harpagophyton* are so efficiently dispersed by animals, whose death they

not infrequently bring about, that their large size is not detrimental except in so far as it limits their number.

The seeds of many members of the marrow family are of only moderate size, but the fruits in which they are contained are among the most diverse in size and form, and some attain large dimensions even in the wild state. They are dispersed by flotation, and after the fruits cease to be buoyant the seeds will often float for weeks.

Unless the dispersal of fruits or seeds be reasonably efficient, it is manifest that no advantage will accrue from a large output and little from a large food supply, and the great diversity of so-called dispersal mechanisms is evidence of their considerable survival value; but beyond a certain efficiency the higher the output consistent with adequate reserves in the seed for establishment, the greater the frequency of the species is likely to be.

It is worth noting that man, in the cultivation of his fruits, has often selected out seedless types. Sometimes this is the outcome of hybridization and resultant genetic infertility; sometimes it is the accompaniment of the mere replication of chromosomes. The seedless banana, the seedless orange and the pineapple are familiar examples of such fruits, which emphasize for us that fruit formation and seed production, though commonly associated phenomena, may be independent of one another. We can indeed, by the use of artificial growth-promoters, cause pears to develop which contain no fertile seeds. In the wild state we find that chromosome replication is not infrequently accompanied by a reduction in fertility but an augmentation of vegetative propagation. Thus, many woodland species that have low seed outputs spread rapidly by runners, of which a striking example is afforded by the lesser periwinkle (*Vinca minor*), which flowers freely but very rarely fruits, yet spreads with remarkable rapidity. The vegetative mode of propagation has many advantages in a shady habitat.

All the evidence we at present possess would appear to lead to the conclusion that seed output is an important factor in successful colonization, and its magnitude is as much a character of the species as height or any other of its variable qualities.

OBITUARY

Prof. P. A. Buxton, C.M.G., F.R.S.

THE news of the death of Prof. P. A. Buxton on December 13 at his home, Grit Howe, Gerrards Cross, shocked and sorrowed his friends and admirers in all parts of the world. Only a year previously he was travelling through difficult forest country in Central America, a few months ago he was still castigating committees with his caustic wit, and right up to the end he was giving that critical help to his colleagues and students for which they will never find a substitute.

Buxton was born on March 24, 1892. He read the Natural Sciences Tripos at Trinity College, Cambridge, and received his medical education at St. George's Hospital. He became acquainted with tropical conditions first during the First World War in Iraq and Iran, then for two years in Palestine and later for two years in the Pacific Islands. In 1926 he became director of the Department of Entomology of the London School of Hygiene and Tropical Medicine, and in 1933 professor of medical entomology of the University of London, appointments which he held until his death. He was elected a Fellow of the Royal Society in 1943, was made C.M.G. in 1947, received the Mary Kingsley Medal of the Liverpool School of Tropical Medicine in 1949 and was awarded the Linnean Gold Medal in 1953.

Buxton altered the course of medical entomology from museum systematics to the study of the living insect, its physiology and its relationship to the environment. His highly original mind was drawn to this practically unexplored field, and a series of classical papers followed. From these observations he was able to synthesize the findings in five books, characterized by the most lucid exposition of the subject. The first, "Animal Life in Deserts", was reprinted in 1955, and is in constant use by a circle of workers much wider than entomologists. Then after his visit to the Pacific appeared three volumes dealing with medical conditions and entomology in Samoa and other islands. His book on the louse went into two editions and is a perfect example of his outlook. Finally, two works on trypanosomiasis and the tsetse fly appeared, first a preliminary memoir and then, just before his death, the comprehensive "Natural History of the Tsetse Flies", a book which all workers in Africa have been awaiting for years.

Buxton's creed may be summed up in his own words: "field observations are a necessary preliminary, but their function is to set problems which should be solved in the laboratory". He communicated this point of view to some carefully chosen students, all of whom have attained positions of eminence in this field; he thus founded a school of thought which has the strongest influence wherever entomology is studied. Buxton's own journeys helped this dissemination, for not only was he widely travelled but also foreigners found him *sympathique*.

The part that Buxton played in introducing the synthetic insecticides into medicine is perhaps not fully recognized. Early in 1943, the insecticide DDT was brought to him from Switzerland, where it had recently been resynthesized; he immediately appreciated its significance, and he was largely responsible for its rapid introduction as an insect killer in the various theatres of the Second World War.

Buxton's advice was sought more and more frequently by committees or councils at home and abroad, and much of his time latterly was occupied in this way; he never really liked this diversion from his research and teaching, but felt that it was his duty as a scientist to give advice to official bodies; and they always got it in forthright terms. He was due for 'retirement' in two years time, and he had already acquired a subject which would have kept him busy for years; he had started studying the breeding of Diptera in fungi, and only twelve months before his death he bought a binocular microscope with which to observe these flies at his house in Gerrards Cross. Many people all over the world will remember his garden there, its interesting plants and trees, and above all, the welcome they received.

P. C. C. GARNHAM

NEWS and VIEWS

Geology at Bedford College, London : Prof. Leonard Hawkes, F.R.S.

THE retirement of Prof. Leonard Hawkes from the chair of geology at Bedford College, University of London, is a milestone in a life devoted to the establishment of a university department renowned for the liberal and cultural bias of its geological teaching. Between the World Wars, as the first occupant of the chair, Prof. Hawkes brought to his task experience gained in the Universities of Durham and Kristiania, and enlivened the substance of his teaching with much original research, some of it exploratory research in difficult ground, on the volcanic history, the petrology and the geomorphology of Iceland. For many years he has been a wise counsellor in geological affairs, notably in the activities of the Geological Society, of which during 1934–42 he was an honorary secretary and afterwards a vice-president; and he is known with affection and regard by many younger geologists as a tolerant and generous friend. His qualities as scientist, educator and administrator were recognized by the award by the Geological Society of the Murchison Medal to him in 1946. His Department did not escape the devastation of war, and in 1945 he was faced with the burden of planning its rebuilding. He leaves Bedford College in the sure knowledge of foundations well laid and superstructure well designed in both material and academic senses.

Dr. Basil C. King

PROF. HAWKES'S successor, Dr. Basil King, has had a varied career in the Colonial Survey service and in universities. A graduate of Durham, London and Glasgow, he was for more than ten years a petrologist and field-geologist in Uganda and Nigeria, where he contributed greatly to knowledge of Pre-Cambrian and igneous rocks, and to the exploitation of economic minerals. Returning to Britain in 1948 to become senior lecturer in the University of Glasgow, he has achieved high distinction for his researches on petrogenesis, notably on rock transformations in the granitic suite. His work on ancient volcanoes is illustrated by reconstructions of former conditions in Arran and in Africa—a continent in which he continues to take an active interest most recently expressed by the survey of an igneous field in Bechuanaland. Latterly, structures in the Scottish Highlands have attracted his attention and are being studied by a small research team under his supervision. A lucid and persuasive lecturer, he is an effective tutor and administrator in university extramural work. By a happy coincidence, he returns to Bedford College as professor in the Department in which he received his first professional appointment twenty years ago.

Physical Chemistry in Queen Mary College, London : Prof. K. W. Sykes

DR. K. W. SYKES, senior lecturer in the University College of Swansea, has been appointed to the newly created chair of physical chemistry in the University of London, tenable at Queen Mary College. Dr. Sykes read chemistry at Oxford, where he held the Rigge Exhibition and Percival Benefaction at the Queen's College. After obtaining first-class honours in 1943, he carried out research on war-time problems under Sir Cyril Hinshelwood for his D.Phil. He remained in Oxford for a further three years as an I.C.I. Fellow, and in 1948 was appointed to a lectureship, and in 1951 to a senior lectureship, in the University College of Swansea. At Swansea Dr. Sykes had the task of completely reorganizing the course in physical chemistry and establishing a school of research. Dr. Sykes's own researches have been mainly in the field of solid – gas reactions, to which he has made distinguished contributions; he has also published important papers on the ferric – iodide reaction and on complexes of the ferric ion. Dr. Sykes is a chemist with wide interests, and his appointment will be a great asset to the growing school of chemistry at Queen Mary College.

Capper Pass Awards for Papers on Metallurgy

THE following Capper Pass Awards have been made by a joint committee representing the Institution of Mining and Metallurgy and the Institute of Metals for papers published during 1954 in the *Transactions* of the Institution and the *Journal* of the Institute: £100 to G. Lawrie Fairs (a method of predicting the performance of commercial mills in the fine grinding of brittle materials); £100 to F. King and Dr. A. N. Turner (control of quality in the hot and cold rolling of aluminium and aluminium alloys); £50 to G. L. Hopkin, Mrs. J. E. Jones, A. R. Moss and D. O. Pickman (arc melting of metals and its application to the casting of molybdenum); £50 to Prof. M. Roy (flotation of oxidized ores of lead, copper and zinc). The Awards are made from a fund given by Capper Pass and Son, Ltd., for the encouragement of scientific and technical papers on processes and plant used in extraction metallurgy and on the subject of assaying, and also papers and processes used in all branches of the non-ferrous metal industry.

Government Support of Agricultural Research in Britain

THE Agricultural Research Bill, which received an unopposed second reading in the House of Commons on December 13, provides that, except for Scotland, the financial and general administration of the grant-aided research institutes in England and Wales, as well as their scientific direction, will be unified under the Agricultural Research Council; the institutes will accordingly be transferred from the Vote for the Ministry of Agriculture, Fisheries and Food to the Vote for the Agricultural Research Council, which will be removed from that of the Treasury and appear under a separate head. It is also proposed to reconstitute the appropriate Privy Council Committee so that in future it consists only of the Lord President of the Council, the Minister of Agriculture and the Minister representing the Scottish Department, and to amend the Charter of the Council so that the two Departments have direct representation on the Council. To avoid constituting the Council as a separate government department and making certain research workers Civil servants, an Agricultural Research Fund is to be set up, which will receive an annual Parliamentary grant-in-aid.

The Bill was introduced by the Minister of Agriculture, Fisheries and Food, Mr. D. Heathcoat Amory, and was also welcomed by Mr. Thomas Williams for the Opposition, who urged the importance of increasing the support for agricultural research. Sir Leslie Plummer pointed out the necessity of planning research for more than one year at a time, and this was widely supported in the debate. It was also suggested that the Agricultural Research Council

should make increasing use of the universities for research. In replying to the debate, Mr. G. R. H. Nugent, the Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, admitted the need for such long-term planning, but pointed out that an annual Vote would be needed, even with a quinquennial programme. He thought the arrangements for disseminating the results of research are working well, and, in reply to questions as to a veterinary research council, said that this had been considered by the Lord President but was thought to offer no advantage at the present time. Eleven of the sixteen experimental farms and six out of seven horticultural experimental farms have been established.

British Section of the International Union for the Study of Social Insects

A NUMBER of entomologists present in Amsterdam at the ninth International Congress of Entomology in 1951 felt that an organization should be formed to bring together those scientists who were engaged in studying the physiology, biology or systematics of the social insects. Thus the Union Internationale pour l'Étude des Insectes Sociaux was initiated, under the presidency of Prof. P.-P. Grassé. The purpose of the Union has since been expanded to include researches on gregarious insects. A Congress was held in Paris in 1952, followed by a highly successful one at Würzburg earlier this year; the next Congress, in 1957, will again be held in Paris. The international journal *Insectes Sociaux*, published in Paris, is completing its second volume. National Sections have been formed in many countries, but until recently British workers in this field have been members of the French Section; however, a British Section has now been formed under the chairmanship of Dr. J. D. Carthy. The subscription to the Section is 10*s*. a year, which includes membership of the International Union, and the Union supplies members with lists of current papers on the subject and notes concerning the activities of the Union as a whole. The cost of *Insectes Sociaux* is 2,000 francs a year for members and 3,000 francs for non-members. The honorary secretary of the new Section is Dr. C. G. Butler, of the Bee Department, Rothamsted Lodge, Hatching Green, Harpenden, Herts, from whom further information can be obtained.

The Breeding of Laboratory Animals

IN the past, experiments on animals were usually done in qualitative terms. To-day biological research has become quantitative in character, and with this approach it is becoming evident that healthy, vigorous and uniform stock is essential for controlled experimental studies and for assaying drugs and other therapeutic agents not susceptible to chemical standardization. What is needed are standardized animals or ones nearly so; Mr. A. L. Bacharach suggests that a standardized animal is to the biologist what a pure reagent is to the chemist. The way in which these animals might be bred was described at a symposium organized by the Laboratory Animals Bureau on May 9, 1955. The subjects discussed included some aspects of animal production for routine biological assay; genetical aspects of the breeding of laboratory animals; the value of littermate controls in endocrinological research; pre-natal and post-natal reproductive wastage; and the problems of a curator of a small animal breeding station at a university. The papers, and some of the ensuing discussion, have now been put together in book form and can be obtained from the Laboratory Animals Bureau, Medical Research Council Laboratories, Holly Hill, Hampstead, London, N.W.3 (7*s*. 6*d*.).

Linen Research Association: Annual Report

IN proposing the adoption of the report of the Council of the Linen Research Association and the accounts at the annual general meeting of the Association on December 16, the chairman, Mr. H. B. McCance, said that the trade subscriptions now amount to £32,385 compared with £7,033 in 1939, and the floor space of the Institute has been increased from 33,408 sq. ft. to 45,837 sq. ft. In seconding the motion, Mr. M. Wallace expressed the opinion that any fundamental change in the basic methods of preparing and spinning flax is unlikely, but that the servo-drafting control mechanism is an example of how new control methods can be applied to improve an old process. The director of research, Dr. A. J. Turner, in his report, instanced the reduction of lick-up on the rollers of preparing frames by simultaneous application of a number of auxiliary devices, as an example of the real progress being made towards the solution of obstinate spinning problems. In the Weaving Department attention has been concentrated on the improvement of the preparatory processes, while in the Chemistry Department much further experience has been obtained of synthetic resin finishes and promising results obtained in applying new synthetic compounds in waterproofing flax canvasses. After stressing the new opportunities for research and the importance of maintaining a scientific staff of high calibre, Dr. Turner said that the Institute's studies of the processing of such fibres as acetate rayon, nylon, 'Terylene' and 'Orlon' have already accumulated a considerable store of knowledge on these fibres, individually and in blends; he expressed the belief that man-made fibres could be introduced with advantage into the textile economy of Northern Ireland and that the dry-spinning industry in Scotland would likewise benefit from these investigations.

Peaceful Uses of Atomic Energy

THE Association of Scientific Workers and the Labour Research Department have produced a useful pamphlet on the "Peaceful Uses of Atomic Energy" (pp. 16; 1955; from the Association; 6*d*.), which is designed to give the ordinary citizen a clear idea of the nature of nuclear science and the nature and possibilities of nuclear power, particularly for Britain, including the uses of radioactive materials. The pamphlet is simpler and much shorter than that of the Central Office of Information on "Nuclear Development" or the White Paper "A Programme of Nuclear Power". Though the pamphlet does less than justice to British developments with radioactive isotopes, it can be commended as likely to assist the general understanding of potentialities in this field. Little is said of the demand its development may make on our resources of materials or of scientific man-power.

Chemistry of Colouring Matters: Symposium in London

A SYMPOSIUM on "Recent Advances in the Chemistry of Colouring Matters" has been arranged by the Chemical Society and will be held in the Royal Institution, Albemarle Street, London, W.1, during

the afternoon and evening of February 2. There will be two sessions, under the chairmanship of Dr. R. P. Linstead and Sir Alexander Todd, respectively, at which papers on the following topics will be read: steric effects in azo and indigoid dyes (Wallace R. Brode); cis-trans isomerism in azo-dyestuffs (R. H. Peters and E. Atherton); synthesis of azaporphins and related macrocycles (J. A. Elvidge); synthetic carotenoids (O. Isler, H. Lindlar, M. Montavon, R. Rüegg, G. Saucy and P. Zeller); and modern theories of colour (M. J. S. Dewar). The papers and subsequent discussion will be published later as No. 4 in the Society's series of "Special Publications". Advance proofs of the papers and admission tickets for those other than Fellows of the Society can be obtained from the General Secretary of the Society at Burlington House, London, W.1, to whom all inquiries relating to the symposium should be directed.

University of London: Appointments

The following appointments have been made in the University of London: Mr. J. G. Ball, head of reactor metallurgy in the Metallurgy Division of the Atomic Energy Research Establishment, Harwell, to the University chair of physical metallurgy tenable at the Imperial College of Science and Technology; Dr. Walter Murgatroyd, principal scientific officer, Atomic Energy Research Establishment, Harwell, to the University chair of nuclear engineering tenable at Queen Mary College; Prof. H. O. W. Richardson, professor of physics in the University of Exeter, to the Hildred Carlile chair of physics tenable at Bedford College; Dr. L. Fowden, lecturer in botany at University College, to the University readership in plant chemistry tenable at that College; and Dr. C. W. Jones, lecturer in applied mathematics in the University of Liverpool, to the University readership in applied mathematics tenable at the Imperial College of Science and Technology.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: D. R. E. Jackson (agricultural officer, Eastern Region, Nigeria), senior agricultural officer, Eastern Region, Nigeria; A. Johnston (plant pathologist, Federation of Malaya), senior plant pathologist, Federation of Malaya; N. W. Smyth (agricultural officer, Sarawak), agricultural officer, Bechuanaland Protectorate; G. A. Southwell (agricultural officer, British Honduras), agricultural officer, Grenada, Windward Islands; R. M. Steven (senior agricultural officer, Sierra Leone), principal agricultural officer, Sierra Leone; J. W. Bride (assistant conservator of forests, Sierra Leone), assistant conservator of forests, Northern Region, Nigeria; J. L. Coldwells (assistant conservator of forests, Gold Coast), assistant conservator of forests, Nyasaland; J. E. M. Horne (assistant conservator of forests, Federation of Nigeria), principal, Forestry School, Federation of Nigeria; J. J. Lawrie (assistant conservator of forests, Somaliland Protectorate), principal forestry officer, Somaliland Protectorate; J. S. Lightbody (assistant conservator of forests, Nigeria), assistant conservator of forests, Kenya; L. A. W. Hayward (senior scientific officer, Federation of Nigeria), principal scientific officer, West African Stored Products Research Unit, Department of Marketing and Exports, Federation of Nigeria; D. L. Johns (research officer, East African Tsetse and Trypanosomiasis Research and Reclamation Organization), senior scientific officer, East African Tsetse and Trypanosomiasis Research and Reclamation Organization; R. Hill, agricultural officer, British Solomon Islands Protectorate; I. M. Johnson, agricultural officer (soil conservation), Kenya; J. M. Bigg and J. R. F. Lushington, assistant conservators of forests, Tanganyika; R. F. Mackenzie, assistant conservator of forests, Northern Region, Nigeria; W. S. Moffat, geologist, Gold Coast; T. L. Gracey, assistant bacteriologist, Medical Department, Jamaica; F. Lothe, pathologist, Medical Department, Uganda; M. W. Service, entomologist, Malaria Service, Federation of Nigeria; M. C. Round, field zoologist, Veterinary Department, Kenya; J. R. Wells, veterinary officer, Uganda; M. J. Cawdery-Hope, scientific officer, East African Tsetse and Trypanosomiasis Research and Reclamation Organization; G. A. H. McClelland, scientific officer, East African Veterinary Research Organization.

Announcements

The Royal Academy of Sciences in Sweden has elected the following to foreign membership: Prof. T. H. Goodspeed, professor of botany in the University of California, Berkeley; Dr. Mervin J. Kelly, president of the Bell Telephone Laboratories; and Sir Geoffrey Taylor, of Cambridge, Yarrow research professor of the Royal Society.

The Esso Development Company has made a grant (for one year in the first instance) to the University College of North Staffordshire to support a postgraduate research student in the Department of Chemistry. The work will be concerned with cationic polymerization, under the direction of Dr. P. H. Plesch.

Three new appointments to senior positions have recently been made in the United Nations Food and Agriculture Organization: Mr. Joseph L. Orr (United States), since 1951 special assistant to the Director-General, will be the Organization's liaison officer at the United Nations Headquarters; Mr. Harold L. Vogel (United States) will be the representative of the Director-General in North America; and Mr. Adolfo Alarcón (Mexico) will be the regional officer for Mexico, Central America and the Caribbean.

The Medical Research Council is offering a further series of fellowships in clinical research, tenable at centres in the United Kingdom during the academic year 1956–57. The fellowships, which may be renewed up to a maximum of three years, are worth £950–£1,100 a year, and are open to medical graduates with some clinical experience who wish to prepare themselves for a career in clinical research. Application forms, to be returned by March 1, and further information can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1.

A symposium on "Perspectives in Marine Biology" will be held in the Scripps Institution of Oceanography, La Jolla, of the University of California, during March 24–31 under the joint sponsorship of the Institution and the United States Office of Naval Research. The discussion will be centred on potential developments in marine biology rather than on past accomplishments, and a large number of scientific workers from outside the United States have been invited to participate. Those wishing to attend should write to Prof. A. A. Buzzati-Traverso, Scripps Institution of Oceanography, La Jolla, Calif.

GENERAL ELECTRIC RESEARCH LABORATORY, SCHENECTADY

NEW METALS AND CERAMICS BUILDING

By ROBERT L. FULLMAN
Materials and Processes Section,
AND
ROBERT M. PARKE
Materials Application and Evaluation Section,
Research Laboratory, General Electric Company, Schenectady, New York

A NEW Metals and Ceramics Building was dedicated late last summer in Schenectady, N.Y., as the facilities of the General Electric Research Laboratory were enlarged. The new building reflects the current widespread interest in research into metals and ceramics, and is part of a 15-million dollar expansion programme now being undertaken at the Laboratory.

The programme of work to be undertaken in the new building includes the following: (1) to ascertain and analyse the areas of most critical need for materials and processes; (2) to develop new processes for new businesses; (3) to develop new materials to improve products; (4) to study existing materials and obtain a better understanding of their properties and processing; (5) to operate pilot plants and obtain economic data.

Dr. J. Herbert Hollomon, manager of the Metallurgy and Ceramics Research Department, has stated that the constant growth of the General Electric Co.—and the ever-increasing diversity of the Company's needs—have necessitated the expansion of the facilities available for such work. "In addition," he says, "it is now more important than ever that the Research Laboratory's scientific understanding should be used for helping to solve any critical problems relating to materials and processes that may stand in the way of Company progress. The organization of the new Metals and Ceramics Building includes the establishment of a group of scientists to seek out and solve problems pertaining to materials and processes wherever they may appear in the Company. Thus, in the new building, amid facilities of both laboratory and industry size, the promising findings of our outstanding group of metallurgists, ceramists, physicists and chemists can be applied to the kind of problems now creating a bottleneck at the designer's level."

One field in which the Metals and Ceramics Building is expected to make significant contributions is in studies of the effect of the 'scale factor' on the properties and processing of materials. Investigation of the effect of large increases in the scale of operations during the transition from laboratory work to production previously has been among the least explored fields of metals and ceramics research. Studies in this field will include the feasibility and the probable cost of factory-size operations.

The General Electric Metals and Ceramics Building is for this reason one of the few facilities in existence which makes available to the research worker production-size equipment unrestricted by the scheduling demands of actual production. When the building was being planned, the size of the machines was to a large extent determined by the quantities of material that would have to be produced in order to make possible a realistic evaluation from the point of view of production. The size of some furnaces, for example, was determined by the smallest quantity of metal that would permit the manufacture of at least one complete product, such as a transformer, for evaluation purposes. The advice of manufacturing components of the Company was, therefore, sought in ascertaining practical limits of equipment capacity for pilot-plant production.

In order to allow the most efficient use of the variety of equipment, the building has been constructed for maximum flexibility, using what has been referred to as the 'erector set' principle. In this method of construction thousands of bolt holes are aligned throughout the structure of the building, permitting easy re-location of equipment. Consequently, as one research project is completed, another may be set up with a minimum of time and effort.

The available processing equipment includes arc-melting furnaces capable of melting highly refractory metals under vacuum and in inert atmospheres. Furnaces of this type are needed because many alloys now under investigation cannot be melted by normal commercial techniques. Vacuum arc-melted ingots of 300 lb. can be produced at the rate of three a day, while it is expected that in the future, by a continuous process, it will be possible to produce ingots weighing four thousand pounds or more. An industrial-type three-phase arc furnace for the preparation of one-ton heats of steel, and induction furnaces for melting metals and alloys in vacuum, controlled atmospheres or in air are also available.

Forming equipment includes a hydraulic extrusion press of 1,250-ton capacity, specially designed for rapid extrusion of super-alloys; a 2,500-lb. drop-hammer; 250-lb. and 2,500-lb. forging hammers; swaging equipment; and a new reversing, two-stand, rod-rolling mill. The rod mill has been designed for high-speed operation, permitting super-alloys to be formed to final size before they cool significantly from the annealing temperature.

A Sendzimir cold mill for rolling metal foils to thicknesses less than a thousandth of an inch, and a Sendzimir planetary hot mill, one of the first, have also been installed in the new building.

Much of the equipment for metal processing will also be used for the melting, heating and shaping of ceramic materials; but certain ceramic presses, furnaces and other equipment have been installed in separate areas to avoid contamination of the material.

The research staff have available throughout the building compressed air, high- and low-pressure steam, city gas, nitrogen, oxygen, standard hydrogen, dried hydrogen (— 90° C. dew point), rough vacuum, distilled water, cooling water, and hot and cold tap water.

THE TEACHING OF CHEMICAL PRINCIPLES

SECTIONS B (Chemistry) and L (Education) of the British Association held a joint discussion on September 6 on "The Teaching of Chemical Principles in School and University". In connexion with this discussion an exhibition of teaching models and demonstrations was arranged by the Chemistry Departments of the University of Bristol.

Opening the discussion, Prof. D. H. Everett (Bristol) said that in the past twenty or thirty years teachers of chemistry have been faced with new problems reminiscent of those raised at the end of the past century by the advent of physical chemistry. There is, he said, less need now to emphasize the principle that the physical basis of chemistry should form a framework for the teaching of chemistry; instead, the more important questions are concerned with the stage at which modern theoretical ideas—quantization of energy and of radiation; wave mechanics; atomic and molecular orbitals; statistical mechanics and thermodynamics—should be introduced, and with the way in which the abstractions with which they deal can be explained to the uninitiated.

The usual university honours course in chemistry has long since ceased to deal with more than a very small fraction of the total extent of chemical knowledge. However, specialization at an early stage in an honours course, with the object of achieving a detailed coverage of a small part of the subject, is undesirable in itself and obscures from the student the power of the underlying principles to unify the subject. It seems more than ever important that chemical education should not only provide the student with a basic knowledge of the facts of chemistry, but should also develop in him an intuition which will enable him to appreciate the significance of new facts as he meets them. It was argued that there should be a place in the university curriculum for a course in chemical principles which would acquaint the student with the more important features of a wide range of phenomena, and which would show how these are linked by fundamental theory. (An extended essay on this theme is to be found in "The Structure of Physical Chemistry", by Sir Cyril Hinshelwood: the treatment in this book is, however, on a more advanced plane than that foreseen by Prof. Everett.) Some more highly specialized topics would be crowded out of the undergraduate into the postgraduate curriculum, but this is not a serious disadvantage. The understanding derived from a course of this kind is more important than an encyclopædic knowledge of chemical facts.

The physical concepts upon which the principles of chemistry are based are nearly all abstract in nature. The ability to appreciate abstract thought develops slowly, and there are in consequence two opposing views concerning the method of introduction of these ideas. Either they should be deferred until the student is more mature, or they may be introduced early in the university course so that he may have time to understand their value by the end of the course. Because of mathematical difficulties, it is impossible to give a rigorous discussion, and so we must be satisfied with an introductory treatment based on models and analogies, which gives a partial understanding. All such simplifications are, however, half-truths, which if applied incautiously can lead to confusion; but if the models and analogies are carefully chosen, and presented with the right emphasis, the dangers of the 'simple introduction' can be minimized. Some ideas implanted in an early course may have to be rejected later, but the student must be prepared to develop his ideas throughout his training: this evolutionary process is characteristic of the development of science as a whole, and a realization of this fact is important to the student.

Prof. Everett expressed the opinion that many of the fundamental ideas can be explained to students at an early stage in their course (Inter. B.Sc. or first-year degree course) by means of simple mechanical models designed to illustrate macroscopic analogies of the molecular situation rather than to represent the actual atomic or molecular state of affairs. He then demonstrated a series of models illustrating, among other things, the quantization of orbits in the hydrogen atom; absorption and emission of energy in definite quanta; the development of the periodic system of elements in terms of the electronic energy-levels; atomic orbitals; molecular orbitals; the free-energy relationships in an allotropic change, and in the solution of a solid in a liquid. More detailed descriptions of these models will be published in the *Advancement of Science*.

Prof. C. A. Coulson (Oxford) read a paper on the "Teaching of Quantum Mechanics to Chemists". He said that no greater change in chemical understanding has ever taken place in modern times than that associated with the advent of quantum mechanics. As a result, to-day no chemical education is worth considering which fails to take account of this development. Yet quantum theory itself is too wide, and too complicated, to present to chemistry students at a university. For practical purposes it seems as if wave mechanics must bear the effective emphasis. This is, by comparison with other forms of quantum theory, relatively simple, and makes more use of conventional ideas such as probability.

Wave mechanics in chemistry is based on two concepts: the idea of quantization, and the description of electron properties. Neither of these is likely to be obvious, despite the efforts of the popular Press. Hence we seek some simple analogy, or model. These analogies and models seem to be of first-rate importance, since without them there is little or no chance that the student will acquire a 'feel' for these modern interpretations. But they are dangerous, and have often led to serious confusion.

Quantization can be approached via the de Broglie relation and the familiar example of standing waves in a violin string. Electron properties—for the chemist—resolve themselves chiefly into probability distributions (or, more simply, the idea of a charge-cloud) and spin. In the first of these the most important factor to stress is shape. It is unimportant in earlier stages to relate these to magnetic properties. There seems no simple model or analogy for electron spin, and all attempts to provide one seem doomed to cause great confusion later. (Physicists may be able to understand the vector model of an atom, etc., but it is doubtful if chemists should be expected to do so.) A simple version of the Pauli exclusion principle is easily written down, adequate to deal with most ground-states of atoms and molecules, and Hund's rules for incomplete shells can be stated plausibly.

Prof. Coulson expressed the view that every chemist should have some familiarity with wave functions, and suggested that the two lowest-energy

states of the hydrogen atom could be worked out by students—this would give confidence that more complete treatments for more complex systems would in fact yield the correct answer.

As an example of the dangers in all elementary accounts, Prof. Coulson cited the frequent misuse of the word 'resonance'. A critique of this concept should be regarded as part of any course on wave mechanics, and leads easily and naturally to a discussion of the true status of wave mechanics, as a most valuable conceptual tool, which gives insight into chemical phenomena, but which is severely limited if accurate *ab initio* calculations are desired. No electronic computer will replace a chemical laboratory.

The third main paper was read by Mr. G. I. Brown (Eton), who gave as the duty of a science master that of understanding the developments in science and interpreting and presenting them in a simplified form to the uninitiated. He considered it important that there should be no undue delay in incorporating new advances into school teaching. This is no easy task for the teacher, and Mr. Brown urged more liaison between active teachers in universities and schools. He welcomed the opportunity for this discussion, also, because it provided a chance of emphasizing the attractions of a teaching career. The teaching of chemistry can be made both interesting and attractive by the variety of possible ways of presenting it, and by the different requirements of students. He stressed that the advanced course of chemistry at school must never be a narrow one, but should give some indication of the importance of all the aspects of chemistry. Each teacher must to some extent decide on the type of approach to be adopted. However, the recent trend towards an undue emphasis on the social and economic aspect was deprecated as one which can too easily give the impression that chemistry is solely concerned with such things as nylon underwear.

Mr. Brown considered that the basis of the course for sixth-form science students should be a theoretical one, involving a study of fundamental chemical principles. Of these the most useful as a unifying framework is modern valency theory. Chemistry is often criticized as a school subject on the grounds that it can be learnt simply by perseverance and hard work, and that it involves too little real thinking. It is true that, below sixth-form level, chemistry cannot fail to be largely a matter of routine learning of apparently unconnected facts—but young boys make no objection to learning the facts, and many have little difficulty in doing so. What is difficult, at this stage, is to exercise the mind of the student in the same way as it is exercised in the learning of, say, mathematics or Latin. There comes a time, usually while still at school, when a boy begins to ask more fundamental questions—and then his mind must be stimulated by something more than a mere catalogue. Mr. Brown expressed his belief that modern valency theory provides the necessary interest, and that despite the criticisms levelled against its introduction in school-teaching, the benefits derived from its use far outweigh the reduction in factual knowledge implied by a change in the balance of study.

Mr. Brown was critical of examining bodies who continue to set questions requiring for their answer the recollection of far too many unimportant facts, and pointed out that the quickest and most effective way of changing the character of school-teaching is to change examination syllabuses and the nature of the examination questions.

The two main contributors to the general discussion which followed were Mr. J. C. Stredder (Tonbridge) and Mr. A. C. Cavell (Uppingham). Mr. Stredder, while not rejecting the incorporation of more recent theories in teaching at school, stressed the dangers of such a policy. He was particularly concerned that an inexperienced pupil, who is unable to criticize—and perhaps unable to understand—the experimental evidence on which modern theories are based, must either allow his critical faculty to be dulled, or must accept such theories as fairy-tales in which he may one day believe. There is a danger that not only facts but also theories will be learned parrot-fashion. Furthermore, the introduction of many modern ideas must depend on the pupil having a sufficient background in physics; and often this cannot be provided adequately at school. Mr. Stredder was of the opinion that, with some exceptions, boys are scarcely ready to be introduced to subjects such as the wave nature of the electron, atomic orbitals, resonance and molecular orbitals until they enter a university.

Mr. Cavell was anxious that developments in chemistry teaching in schools should take account of the educational as well as the more specialized technical aspects. He expressed the view that both schools and universities are attempting to teach too wide a syllabus in science, and that by introducing too much detail, insufficient time is available for dealing with basic principles. While agreeing with Mr. Brown that modern valency theory helps to make sense of chemistry, and encourages thought and discussion, Mr. Cavell said that in his experience the evidence provided by school certificate scripts suggests that either this approach is not being widely used, or that candidates are averse to using it in answering examination questions. His agreement with Prof. Everett, that a rational rather than a strictly historical approach is to be preferred, was qualified by the view that one of the fundamental educational weaknesses of science is that it deals more with things than with people. Consequently, he argued, no opportunity should be lost of introducing historical and biographical detail in an attempt to humanize the subject. Mr. Cavell also appealed for closer co-operation between teachers in school and university, especially in connexion with the revision of school syllabuses, the provision of courses for science teachers at universities, and on detailed techniques of science teaching.

PROPERTIES AND DISTRIBUTION PROBLEMS OF RAW COTTON

A ONE-DAY conference on "Raw Cotton, its Properties and Distribution", arranged by the Manchester and District Section of the Textile Institute, was held in Liverpool on November 23 to facilitate the participation of raw-cotton merchants in discussing current problems in the growing and marketing of raw cotton with the spinning and weaving sides of the cotton industry. It was also hoped that the conference would illustrate part of the wide field of activities undertaken by the Textile Institute and so encourage the formation of a Liverpool section. Four papers were presented for con-

sideration and discussion: genetics, by Prof. S. C. Harland (professor of botany in the University of Manchester); cotton quality and its assessment, by E. Lord (British Cotton Industry Research Association); spinners' requirements, by A. Draper (William Birtwistle Allied Mills, Ltd., Preston); and supply and marketing, by W. B. Hutchinson (Major Cleaver and Co., Liverpool).

Partly through necessity, the cotton industry is accustomed to handling variable material, and both marketing and industrial processing are organized to minimize the effects of quality variations. Prof. Harland outlined how large differences between the main groups of commercial cottons are mainly genetical in character, but environmental factors also produce appreciable effects. Variability in the many characters of the fibres in a given cotton sample starts with marked regional variation over the surface of the seed and is progressively increased by additional variation associated with seed to seed, boll to boll and plant to plant differences. Samples of the same strain, but different origin, often show pronounced locality and seasonal effects. Yield is of paramount importance to the grower and so far has received the most attention in the breeding programmes of various research stations. Nevertheless, cotton quality can be improved appreciably by the applications of genetical methods, both by reducing the variability and increasing the average fibre quality. Some past achievements along these lines in various countries were reviewed, and Prof. Harland also pointed out that as yet we are not able to formulate or even envisage the future upper limit that it may be possible to reach by cotton breeding. A valuable development during recent years is the increasing use of spinning tests to measure directly particular yarn features in preference to the previous almost complete dependence on a range of individual fibre tests.

For many years, and still to a large extent, the various features of raw cotton have been appraised commercially by subjective methods, particularly by making assessments based on the visual appreciation of appearance and on tactile impressions noted during manual manipulation of the fibres. A high degree of skill in the classification of cotton quality may come with long experience; but it remains largely a personal matter. Mr. Lord reviewed many of the 'laboratory' methods which have been developed to furnish separate objective evaluations of the various characteristics affecting cotton quality and commented on their accuracy, ease of use, limitations and scope of application. Determination of fibre length may be effected in several ways. In some methods, complete estimation of the several aspects of the distribution of fibre length may be made by tests largely dependent on the skill of the operator. In others, special fibre arrangements may be prepared and measured by the use of photo-electric scanning devices. The cotton fibre is a hollow, flattened and twisted single cell which grows out of the epidermis of the seed. Both perimeter and the degree of wall thickening are of industrial importance; but direct rapid measurement of these features is not generally feasible because of difficulties of technique and the high inter-fibre variation. Tests based on the determination of the weight per unit length and on the microscopical classification of swollen fibres have been developed to furnish indirect estimates of fineness and thickening. These methods have found widespread application, although they are slow in the light of classers' requirements. Measurement of the air permeability of compressed plugs of cotton fibres affords a rapid and reasonably accurate method of assessing specific fibre surface. The specific surface is determined both by the fibre fineness and the cell-wall thickening, and hence the practical interpretation of flow estimates demands care. Fibre strength is of prime technical importance and is most easily measured on bundles of parallel fibres. The structure and growth of cotton are such that weak places occur at irregular intervals along each fibre, and this leads to a marked dependence of measured fibre strength on the length of test specimen, so that no single set of experimental conditions affords a means of fully assessing the separate strength characteristics. Cotton 'grade' was another feature briefly reviewed at the conference. The 'Shirley' analyser is a mechanical tester for the determination of the trash or foreign content of cotton, one quantity largely influencing the classified grade. The assessment of particular reflectance characteristics of cotton may be made on the automatic Nickerson–Hunter cotton colorimeter. Observations on this instrument correlate well with the visual grade classifications of American cotton. Commercial applications of the colorimeter are limited by the price, but its use in maintaining a regular check on the choice and formation of physical standards of grade is now established in the United States and should prove valuable in avoiding small but progressive changes which have occurred in the past.

Mr. Draper commented further on the application of fibre and spinning test methods to the choice and classification of raw cotton. Most objective tests are still too lengthy to permit their being applied to all commercial samples. Nevertheless, there is a strong need for representative scientific data to be available to the grower, merchant and spinner in order to encourage the production of more suitable material and to detect quickly those growths in which deterioration is occurring. He felt that in some instances the side of the industry concerned with growing might have exploited scientific tests to indicate how closely quality can be cut without incurring undue complaint instead of exploring more fully the possibilities of developing new strains of better general quality or with specialized characteristics for competing or blending with man-made fibres. Mr. Draper also outlined in detail some of the ways in which practices of merchanting raw cotton in Great Britain might usefully be extended in order to meet more satisfactorily the requirements of the spinner.

Mr. Hutchinson surveyed the basic principles of the organization of cotton marketing. The present pattern in Britain has been gradually developed to fill many varied needs. It must provide a selling link between the small grower and the consumer and maintain classification methods to ensure reasonable continuity in quality despite regional and seasonal fluctuations. Marketing organization on a wide scale requires a complex price-structure to cope with rapidly changing supply and demand, with intermittent government interference through monetary controls and crop limitations, and with the problems arising through price changes during the often lengthy period which elapses between harvesting the crop and the final production of textile articles. The use of scientific tests to determine cotton quality is a development of significance which cannot be ignored. Merchants must examine these methods

and place them in proper perspective in the general framework of trading. Stress was laid by Mr. Hutchinson on the need for merchants and also spinners to have the fullest information available about the various characteristics of both main growths and new varieties. He said that at first it would probably be found better to superimpose any new tests on the established systems of classifications than to set up new systems. Nevertheless, marked additional sub-classification would certainly give rise to serious marketing difficulties. Selling would be made more complicated because many test results cannot be used as a basis for trading values, choice of material might be more restricted, and prices would be increased by higher classification costs, while adequate cover against price changes could not be arranged to cope with a multiplicity of qualities. There might be more scope for the use of scientific tests in normal 'spot' trading of cotton for immediate consumption than in 'futures' trading for covering price changes.

SYMPOSIUM ON THIOCTIC ACID

A SYMPOSIUM on the chemistry, biochemistry and pharmacology of thioctic acid was held during November 28 and 29 at the Institute of Pharmacology of the University of Naples. There were about a hundred participants, including Profs. Bovet, Chain, Condorelli and Rossi-Fanelli (Rome), Prof. Theorell (Stockholm) and Prof. Vannotti (Lausanne), apart from the speakers.

The symposium was introduced by Prof. D. Marotta, director of the Istituto Superiore di Sanità (Rome), and the first lecture was given by Prof. M. Calvin (California), who discussed the part played by thioctic acid in the photosynthetic cycle. Prof. Calvin reported the isolation, with the help of ^{35}S-labelled thioctic acid, of the natural active form from the plastids of algae. It is probable that, in this form, the carboxyl group of thioctic acid is bound in an ester linkage to a hydroxyl group of glycerol.

Prof. E. A. Braude (London) followed with an account of the synthesis of thioctic acid. He described a new method which affords a good overall yield in few steps and represents the first application of the Prins reaction (addition of formaldehyde to an olefin) to the synthesis of a natural product.

The pharmacology of thioctic acid was discussed in a lecture by Prof. L. Donatelli, who stated that the lethal dose in rabbits, mice and other animals lies between 100 and 220 ml. per kgm. weight. A strong antitoxic action of thioctic acid was demonstrated for acute and chronic poisoning by mercuric chloride, arsenite, arsenobenzoles, carbon tetrachloride, aniline and *iso*nicotinic acid hydrazide. A remarkable diuretic and choleretic effect was also observed in the rabbit.

The second day was devoted to the physiopathology and therapeutic applications of thioctic acid. Prof. P. Larizza (Cagliari) reviewed present knowledge on the part played by thioctic acid in biochemical processes and illustrated his experiments on phosphorus poisoning and steathogenic (Handler) diets in which thioctic acid normalizes the fat content of the liver. Prof. F. Rausch (Bad Rothenfelde) reported on the applications in human pathology, particularly in the awakening action on liver coma patients. This effect was confirmed by Prof. A. Colarusso (Naples), who also discussed the liver-protecting action in hepatic cirrhosis and various forms of hepatitis. He noticed a remarkable diuretic-effect on some of his patients with liver cirrhosis and congestive heart failure. The dose used was of the order of 20–50 mgm. per day, usually injected intravenously.

From these lectures and from the lively discussion which followed, it was clear that thioctic acid, apart from playing an important part in plant metabolism, may be a useful therapeutic agent, especially in diseases of the liver.

A. SEGRE

WATER RESOURCES OF GREAT BRITAIN

ALONG with the news of the reconstitution of the Central Advisory Water Committee (*Nature*, October 22) comes the welcome reappearance of "The Surface Water Year Book of Great Britain"*. A complete survey of inland water resources involves details of rainfall, surface water and ground water. The "Year Book" provides information about the surface water resources of most drainage areas and their rainfalls, and rather more detailed information relating to rainfall alone is issued annually in "British Rainfall", published by the Meteorological Office. Details of ground water resources are not yet available, but active steps are being taken to acquire and issue this information.

The first three "Surface Water" volumes dealt with the periods 1935–36, 1936–37 and 1937–45, and the fourth and present volume with the eight water years 1945–53. In the first two volumes the measurements reported were collected from various public and private organizations, and the distribution of the records was very uneven. This was improved in the third volume, and a further notable increased coverage occurs in the fourth volume largely as a result of the River Boards Act of 1948.

In the present volume Great Britain is divided into 103 areas, each area corresponding to one or more river basins. Within each area there is, first, a general description of the region, the gauging stations and the records available. Monthly evaluations of the average general rainfall over the drainage area for the standard period 1881–1915 are given, and then follow tables of monthly discharges and run-off, together with monthly evaluations of the general rainfall. An indication of extreme discharges is also given.

Thus the presentation of the data, so far as the monthly flow records are concerned, closely follows the pattern of the third volume, but the new volume does not give daily discharges for each station or the tables of frequencies. The possible inclusion of these data and other relevant information is, however, under consideration for the next issue, which it is hoped will cover only one water year. Meanwhile, the issue of the fourth volume is a notable step towards the systematic collection and dissemination of the basic data necessary for the formulation of a much-needed national water policy in Great Britain.

W. G. V. BALCHIN

* Ministry of Housing and Local Government: Scottish Office. The Surface Water Year Book of Great Britain, 1945–53. (Hydrometric Statistics for British Rivers, together with related Rainfalls, for the Eight Years ended 30th September, 1953.) Pp. xl+167. (London: H.M.S.O., 1955.) 35*s.* net.

SCIENCE IN THE UNITED STATES DURING 1954

THE third report of the British Commonwealth Scientific Office in Washington, D.C., entitled "Notes on Science in U.S.A., 1954"*, covers 1954 and is not so specifically linked with the United States fiscal year as the two previous reports. During the period under review, the only legislative activity directly affecting science was the passing of the new Atomic Energy Act, which permits an increased release of information on atomic energy to American industry and exchanges with other countries. While the possibilities of exchanging military-type information are limited, there is wide scope for co-operation on the peaceful uses of nuclear energy. The five-year nuclear power programme of the Atomic Energy Commission, which was approved in March 1954, calls for research and development at a cost of 8·5 million dollars a year and a total estimated expenditure of 199 million dollars on five specific projects on reactors of the following type: pressurized water; sodium graphite; boiling water; homogeneous; and fast breeder. Besides this, the United States Navy has expanded its programme of nuclear-powered vessels, and the Air Force is developing nuclear-powered aircraft. For the Army, a power plant, the so-called Army Package Power Reactor, is being constructed; this will develop about 2,000 kW. of electricity, and the components will be transportable by air. The Commission has replaced the previous 'study' agreements with industry by three types of participation agreements, and it was estimated that perhaps a hundred new participating agreements would be signed in 1955 in addition to the twenty study agreements by the end of 1954. In the field of particle accelerators the Commission has approved the design and construction at the Brookhaven National Laboratory of an ultra-high-energy alternating-gradient synchrotron for producing beams of protons of energies ranging up to 25,000 MeV. The value to industry of radioisotopes is now estimated at a hundred million dollars a year, and that of the ancillary industry of making instruments for the detection of radiation is expected to reach thirty-five million dollars a year by 1956. The Commission is constructing a new 200,000-dollar plant for processing radioiodine and has made available to industry the irradiation facilities of the high-intensity 30,000-kW. Materials Testing Reactor at Arco, Idaho, while a 90,000 dollar gamma-radiation plant is being constructed at Argonne primarily for use by the Army in studying food preservation. A note on nuclear developments in Canada directs attention to the valuable information which has been gained in restoring the 30,000 kW. reactor at Chalk River (called NRX). The reactor is now operating at 40,000 kW., and this greater power will reduce the time for research experiments and the production of isotopes, as well as permit tests on components for the new reactor to be made under irradiation more nearly comparable with actual conditions of exposure.

Referring to the President's Executive Order of March 1954, reiterating his support for the National Science Foundation, the report points out that the Order is important as indicating the Administration's intention that the Foundation shall be the cornerstone of the basic research effort of the United States.

* British Commonwealth Scientific Organization (North America). Notes on Science in U.S.A., 1954. Pp. iv+39. (London: H.M.S.O., 1955.) 2*s.* net.

Federal expenditure on research and development in 1954 is estimated at 2,095 million dollars, or 3·1 per cent of the total budget, and roughly half the national expenditure on research and development. Of this, 1,530 million dollars went to the Department of Defense, and, including all the work of the Atomic Energy Commission and of the Advisory Committee for Aeronautics, the proportion concerned with defence was 90 per cent. About 250 million dollars was spent on new facilities and equipment. In view of the complexities of the relation between the National Academy of Sciences and the National Research Council and of the slight understanding of those outside the United States of the relation of the Academy to the Government, the functions of both bodies are explained at some length. During 1952–53 about three-quarters of their income of 6 million dollars came from government contracts and grants.

Academic research on solid fuels was reduced in volume during the year; but in view of the state of the coal industry a programme to develop new, and maintain existing, markets for coal has been initiated. A joint survey of the comparative economics of the electric furnace and the open-hearth furnace for the production of low-carbon steel indicated substantial advantages for the electric furnace; but a complete change-over to electric furnaces would require a 12 per cent increase in the output of electricity and 25 million tons a year increase in coal consumption. In the new programme on synthetic liquid fuels emphasis has been placed on catalyst development, while in coal hydrogenation the aim is a one-stage high-pressure process giving high yields of gasoline; the chemistry and physics of the processes are receiving more fundamental study. Little further work on the gasification of coal at atmospheric pressure is contemplated, but construction of an improved pressure-gasifier at the new research station at Morgantown continued; this may permit a two-thirds reduction in the cost of compressing synthesis gas before its use in methyl alcohol, ammonia or Fischer–Tropsch synthesis. The possibility of transporting liquid methane in ships containing tanks internally insulated by a thick layer of cemented balsa wood sections is being examined, and increasing attention is being given to atmospheric pollution, on which ninety-eight laboratories in the United States were working during 1953. In the Detroit (Michigan)–Windsor (Ontario) area an International Air Pollution Study is in progress in which an international technical advisory board co-ordinates the activities of both United States and Canadian authorities, and co-operation has also been secured in attempts to reduce smoke emitted by vessels plying the Detroit River.

Interest in solar energy is expanding, and at a conference at Madison, Wisconsin, in June 1953 graphical methods were demonstrated for analysing the economics of collector design; the basic mechanism of photosynthesis was discussed from the point of view of quantum mechanics and thermodynamics, and of photolytically induced endothermal chemical reactions, while the Bell Telephone Co., Inc., has announced a photoelectronic cell consisting of a very thin plate of metallic silicon yielding, in full sunlight, power at the rate of about 50 watts per sq. yd. The mass culture of algae is also receiving much attention, and a feature of a symposium at the Boston meeting in December 1953 of the American Association for the Advancement of Science was the disclosure that much of the present work is with algae other than *Chlorella*.

Although water is an abundant resource in the United States, it can no longer be taken for granted, and the rapid increase in the use of ground water for air conditioning appears to be causing concern; but there appear to be insufficient data on water losses in all phases of the cycle of water supply and use. Active work continues on the desalting of water; but nothing yet published suggests that provision of irrigation water in quantity by this method is approaching economic possibility. In agriculture the main development during the year, especially in the western States, was the use of liquid fertilizers. Several nitrogenous solutions are on the market, and other solutions, containing nitrogen, phosphates and potash, are available for use with low-pressure spraying equipment or for insertion into irrigation water. As regards insecticides the present trend is to concentrate on substances which can be absorbed into the plant system and, by their presence in the plant cells, prevent attack by insects or infection by disease. Growth-regulating substances are being used not only for removing unwanted plants but also for controlling the rate of development of ornamental shrubs, to delay the flowering of fruit trees, and even to retard the growth of lawn grass. In animal production, the main developments on the nutrition side have been the use of antibiotics to accelerate the fattening of cattle, and the evolution of a system by which pigs can be weaned at five days old. In 1952, about 30 per cent by weight of all antibiotics produced in the United States was fed to farm animals. Further developments by industrial interests and by the official research centres during 1953 and the first half of 1954 may well make 1954 the last 'experimental' year in regard to the full-scale commercial production in the Americas of kenaf, the jute substitute. The problem of mechanical harvesting has not been solved, however, but chemical retting may go far to place the industry in a strong position.

In metals and metal physics, work on the sintering of iron ores has received considerable impetus, and many trials have been made with a high proportion of sinter in the burden. Attention is being given to the development of domestic sources of supply of titanium, and a new plant, with an annual output of a hundred thousand tons of ilmenite, is under construction in Florida; it is of the 'travelling lake' type and uses a battery of Humphrey spirals on a raft which floats in a lake of its own making and proceeds through the deposit as ore is taken in at the front of the raft and waste material discharged at the rear. Several firms have been working on the casting of titanium and titanium alloys, and the major difficulty of surface contamination appears to have been overcome. The potentialities of the Colorado Plateau as a source of uranium were emphasized during the year, and the release of the classified metallurgical work on beryllium has permitted a comprehensive view of the present state of beryllium metallurgy in the United States. Satisfactory methods are now available for the metallographic examination of beryllium and its alloys; but, apart from an aluminium casting, no beryllium-rich alloy is known to be in use, although beryllium might find extensive use in reactors if the cost were reduced to 25 dollars/lb. of pure beryllium raw metal. In fundamental research, much work is being done on single-crystal specimens, whereby grain-boundary effects and some other variables are eliminated. Interest is widespread in the development of chemical methods for the extraction of metals, in place of normal smelting procedures, to which low-grade ores, tailings and slags are often not amenable, and considerable attention has been paid to low-grade domestic sources of manganese, as well as to the extraction of copper, nickel, cobalt and uranium from low-grade ores. In 1953 the sale of synthetic detergents in the United States exceeded for the first time that of soap, and this increasing use is presenting problems of sewage disposal and water supply, particularly the growing use of non-ionic materials, which now account for 10 per cent of the production. There is also evidence that detergents may have a deleterious effect on the sewage-digesting bacteria.

Several research groups are considering the possibilities of mechanical aids to translation, and a feature of this report is a brief but excellent bibliography of recent articles and reports.

DETECTION OF ATMOSPHERIC DUST AND TEMPERATURE INVERSIONS BY TWILIGHT SCATTERING

By Dr. E. K. BIGG

Division of Radiophysics, Commonwealth Scientific and Industrial Research Organization, Sydney

THE detection of meteoritic dust and the tracing of its passage through the atmosphere is important in view of the evidence produced by Bowen[1] that rainfall (when added for many stations or many years) is correlated with the advent of meteor showers. Discontinuities in the scattered sunlight during twilight have been reported by Grandmontagne[2] and de Vaucouleurs[3], and the hope of displaying these more prominently and perhaps identifying them with regions of dust led to the experiments to be described.

During twilight, light received from a cone of 1° vertical angle was recorded by a photocell with filter at the focus of a large lens. The light was interrupted 250 times per sec. by a rotating slotted disk, and the alternating current from the photocell amplified and balanced against a fixed voltage, the difference between the fixed and varying voltages being read at 10-sec. intervals. Whenever the difference reached a certain level, it was reduced to zero by adjusting the gain of the amplifier. The rate of change of the deflexion of this meter was then approximately proportional to the ratio of the rate of change of illumination (dI/dt) to the illumination (I).

To emphasize the contribution of dust particles to the scattered light, the large forward scattering of particles comparable in size with the wave-length was utilized by looking in the vertical plane containing the sun at an angle of 20° to the horizon. Height was defined by the intersection of the grazing ray from the sun's centre with the line of sight, with a fixed allowance of 68′ for refraction. To make the shadow as sharp as possible, only light of red and infra-red wave-lengths was accepted by the equipment.

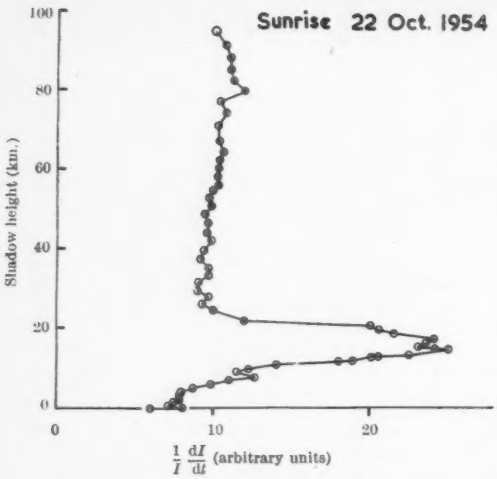

Fig. 1

The present results were obtained during October 19–November 30, 1954, near Alice Springs (lat. 23° S.) in Central Australia, a dry, cloudless climate being essential for the experiments. There was a nearby radio-sonde station from which temperature soundings were made daily shortly after noon. A fuller description of the observations at this and two other sites has been submitted for publication to the *Journal of Meteorology*.

Scattered light was detected for shadow heights exceeding 100 km., but was not recorded because of the high proportion of secondary scattering. Regular features of the twilight curve of $\frac{1}{I}\frac{dI}{dt}$ were a large maximum near 15 km., a long constant portion and second maximum near 80 km., the relative sizes in arbitrary units being 15–50, 10, 10–13 respectively. A typical example is shown in Fig. 1.

A specific example serves to illustrate the nature of the lower maximum. In Fig. 2 is shown a temperature sounding showing inversions *A*–*E* and the following twilight curve with maxima *A*′–*E*′. The interpretation of the similarity is that a maximum of $\frac{1}{I}\frac{dI}{dt}$ occurs at the boundary of regions of different dust content—a boundary usually being a temperature inversion. In cases where the only inversion was the tropopause, the peak in $\frac{1}{I}\frac{dI}{dt}$ was also usually single, and the heights of the tropopause and the peak varied from day to day in a similar way. The size of the largest maximum in the twilight curve varied greatly and was correlated remarkably with surface pressure 60 hr. later. This is thought to mean that instability in advance of cyclonic conditions led to upward transport of dust which accumulated at the tropopause. The possibility of detection of meteoritic dust by the twilight method at this level is therefore slight, because of the relatively large quantities of dust of terrestrial origin.

The long part of $\frac{1}{I}\frac{dI}{dt}$ between 25 and 75 km. was, on the average, constant but contained some short-lived irregularities which had usually disappeared by the following twilight. If these represented falling dust layers, the inference is that the dust was patchy or soon mixed vertically.

The maximum in the curve near 80 km., although smaller than that at the tropopause, was of great interest as it seemed likely to be associated with the temperature inversion known to exist there. Calculations indicate that molecular scattering alone is

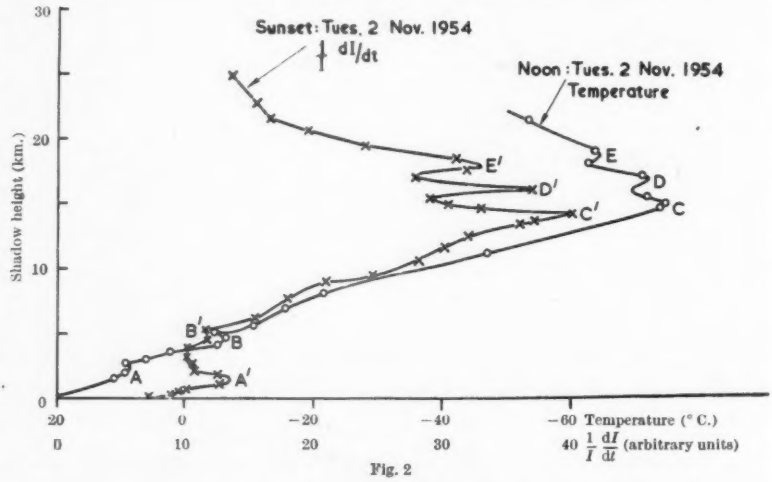

Fig. 2

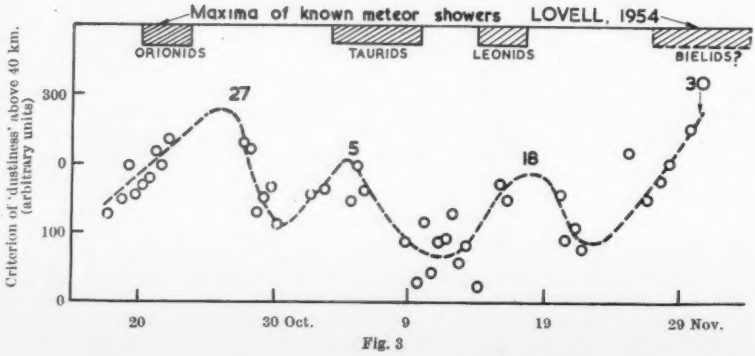

Fig. 3

unlikely to account for the day-to-day variations found at this height, so that they are due, at least partly, to scattering from larger particles. The area under each curve was therefore integrated between 90 km. and 40 km. to obtain an arbitrary criterion of 'dustiness' in the upper atmosphere, and it was found that some systematic variations existed. These are shown in Fig. 3, and it can be seen that, in spite of scatter, there seems to be a tendency to maximum values at about the time of maximum of meteor showers.

Because the meteor showers of this period have relatively broad and ill-defined maxima, they are not well suited to test Bowen's theory of the meteoritic influence on rainfall. The maxima shown in Fig. 3, though somewhat subjective, provide fairly definite dates which can be used to check the 30-day lag which Bowen found between the advent of the meteoric dust in the atmosphere and the associated rainfall peak. A compilation of fifty years rainfall from about 250 stations for this period, prepared by Bowen (private communication), has maxima on November 27, December 5 and December 29—each about thirty days after high values of 'dustiness'.

The average height of the upper maximum in the twilight scattering curve, which is believed to be associated with the temperature inversion at about that height, was found to be 81·1 km. for the thirty-two occasions in this period when it was well defined, the extreme variability being ±5 km. An interesting feature of the scattering near 80 km. was the formation of a double maximum, which occurred on days near the peaks in Fig. 3.

The experiments described offer a novel method for detecting inversions in the troposphere and for studying the height and form of the discontinuity near 80 km. The observations so far made are consistent with Bowen's rainfall–meteor dust hypothesis, but provide no conclusive evidence to support it. [July 28

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STRUCTURES AND FUNCTIONS OF THE PHENOLASE COMPLEX

By Dr. H. S. MASON

Department of Biochemistry, University of Oregon Medical School, Portland, Oregon

THE phenolase complex, widely distributed throughout the phylogenetic scale, consists of two enzymic activities, phenol *o*-hydroxylase ('cresolase', equation 1) and *o*-diphenol dehydrogenase ('catecholase', equation 2). These activities have

$$\text{Monophenol} + \tfrac{1}{2}O_2 = o\text{-diphenol} \quad (1)$$

$$o\text{-Diphenol} + \tfrac{1}{2}O_2 = o\text{-quinone} + H_2O \quad (2)$$

now been investigated for sixty years[1], and from the results which have been obtained, two interesting problems have emerged: What is the chemical basis of cresolase activity? And what is the relationship between cresolase and catecholase activity? In this communication I propose to develop a new theory of the mechanism of reactions catalysed by the phenolase complex, a theory which appears to give the most plausible solution of these two problems.

The catalytic activities comprising the phenolase complex possess the following characteristics: (*a*) they occur together[2,3], and have been found associated with the same electrophoretic and ultra-centrifugal component[4]; (*b*) in any preparation of the phenolase complex, they are inhibited to the same degree by metal-binding reagents, and substrates for one activity competitively inhibit the other[5–8]; (*c*) each activity has been found proportional to copper content[4,7–9]; (*d*) both activities are lost when copper is removed from holoenzymic preparations and reconstituted when copper is added to the inactive apoenzymic product[8,10]. Furthermore, it has not been possible to remove catecholase from cresolase activity[4,7,10–12].

While the two reactions catalysed by the phenolase complex are very dissimilar, the corresponding enzymes appear to be associated with the same active site. Since the catalysis of two types of reaction by a single catalytic configuration is a situation rare in biochemistry, the possibility of its occurrence deserves close scrutiny. Thus, it has not been possible to remove catecholase activity from cresolase, but considerable purification of catecholases themselves has been achieved[4,7,8]. During these purifications the cresolase activity is, however, destroyed rather than separated, and the ratio of the two activities in the phenolase complex can readily be altered by mild physical treatment, such as warming or adsorption, or even standing at −72° in lyophilized form. In addition, the residual cresolase in high catecholase preparations has a characteristic lag or induction period toward monophenolic substrates which is absent in crude extracts and is specifically abolished by traces of *o*-diphenolic substrates for catecholase[7,8,13]. A quantitative (inverse) relationship exists between the concentration of this *o*-diphenol and the length of the induction period[13]. Non-specific shortening of the induction period also takes place in the presence of reducing agents such as ascorbic acid and hydroquinone, which are not themselves *catalytically* oxidized by the phenolase complex[6,14].

Mechanism of Cresolase Action

A number of mechanisms have been proposed to explain these observations. The reader is referred to recent review articles for historical and bibliographic details concerning them[2,3,15]. For the present purposes, it is sufficient to recall that these hypotheses fall into enzymic and non-enzymic classes. According to the latter concept, the quinonoid product of the catecholase reaction (equation 1) is an active oxidant in the cresolase reaction, in the sense shown by equation 3:

$$\text{Monophenol} + o\text{-quinone} + H_2O = 2\ o\text{-diphenol} \quad (3)$$

Molecular oxygen is thus consumed only to form *o*-quinone, and the oxygen of the freshly introduced hydroxyl group must arise from solvent water. In order to test this theory and to learn more of the mechanism of cresolase action, we have recently

conducted the hydroxylation (of 3,4-dimethylphenol) in environments of oxygen-18 and water, and oxygen and heavy water ($H_2{}^{18}O$), and have determined the heavy-oxygen content of the 4,5-dimethylcatechol which was formed in each case[16]. The results are given in Table 1. Clearly, the oxygen of the newly introduced hydroxyl group arises from molecular oxygen. None comes from solvent water, nor is there any apparent exchange of solvent oxygen with molecular oxygen during the process. It is therefore certain that the mechanism described by equation 3 cannot operate during cresolase action. This is quite consistent with a number of other observations which make a non-enzymic basis for cresolase activity unlikely, such as the ortho-position and optical specificities of cresolase[10,13,14], the inability of quinones generated by other enzymes to hydroxylate monophenols[11,17], the high level of cresolase activity possible in the presence of strong reducing agents[6], and the changing ratios of cresolase to catecholase activity during purification[4].

Table 1. Uptake of Oxygen-18 from Oxygen-18 and from $H_2{}^{18}O$ during the Enzymic Hydroxylation of 3,4-Dimethylphenol in the Presence of Mushroom Phenolase

Experiment	Per cent of theoretically possible uptake of oxygen-18
1. $^{18}O_2$ + H_2O	89 88, 95
2. O_2 + $H_2{}^{18}O$	0, 0

Since, therefore, cresolase activity is an enzymic rather than a non-enzymic process, molecular oxygen must combine at some stage with enzyme or enzyme-substrate complex. There is a growing consensus of opinion[4,6,15,17-19], to which I subscribe, that the *o*-diphenol-sensitive induction period of cresolase, the changing ratios of activities and the dependence of both activities upon a copper-containing protein can best be explained in terms of a single enzyme possessing two characteristic activities. In the form proposed by Dawson and his co-workers[4], this hypothesis provides that, during the oxidation of an *o*-diphenol by the phenolase complex, a portion of the enzyme becomes momentarily activated or primed, so that it can bring about the hydroxylation of monophenols. It is for this reason that the enzyme is cresolase-active when simultaneously oxidizing *o*-diphenols[6,20,21-24]. The changing ratios of cresolase to catecholase activity during purification of the phenolase complex are ascribed to fragmentation of the phenolase complex, and to loss of copper-free portions of the enzyme which must in some way be important to cresolase activity. The molecular sizes of different preparations are thus different, but the number of copper atoms per molecule (four) presumably remains constant. Since copper forms only a portion of the cresolase-active centre according to this concept, only the catecholase activity should be proportional to the copper content of high catecholase preparations, and this is indeed the case. However, the terms 'priming', 'activation', and 'fragmentation' are vague and their physico-chemical basis is ambiguous, considering that it has not been possible to obtain cresolase preparations sufficiently homogeneous.

On the other hand, evidence concerning the number and valence of the copper atoms at the catalytic sites of the phenolase complex together with the results of the oxygen tracer study make it possible to offer a more plausible explanation of the mechanism of catecholase and cresolase reactions catalysed by the same copper protein (phenolase). Thus, in the presence of one molecule of *o*-diphenol, two cupric atoms in phenolase are reduced to cuprous atoms[6]. Since hydroxylation by phenolase cannot take place in the absence of *o*-diphenols[13,21-24] or other reducing agents[6,14,20], cresolase activity has its initial basis in reduced phenolase, that is, cuprous enzyme. *o*-Diphenols act as the heat-stable substances which Keilin and Mann[7] have suggested as a requirement for cresolase activity, and thus have a dual function as specific cresolase activators and as catecholase substrates. Furthermore, one molecule of carbon monoxide is bound per two atoms of cuprous phenolase copper[6]. It is therefore likely that the catalytic configuration involved in cresolase activity consists in two neighbouring cuprous atoms attached to protein, and that one molecule of oxygen may combine with this structure, which accordingly bears a strong analogy to that of hæmocyanin[6,25,26]. Differences in the mode of attachment of copper to protein which lead to a different distribution of electrons around the oxygenated complex may account for the reversible coupling of molecular oxygen by hæmocyanin on one hand, and hydroxylation of the benzene ring by phenolase on the other. On these grounds, the mechanism of cresolase action may be expressed by equations 4, 5 and 6. One atom of oxygen is consumed by the hydroxylation reaction during this sequence. The second atom is reduced to water, a process which requires two electrons. Two cuprous atoms supply them, and at the end of the hydroxylative phase (equation 5) this pair must then be in the cupric or inactive state, and require reactivation by the oxidation of *o*-diphenol, as depicted in equation 7. It also seems probable that steps 5, 6, and 7 occur in one stage, as shown in equation 8, the phenolic substrate displacing a water of hydration at the copper to form an activated ternary complex, which dissociates directly to *o*-quinone.

$$\text{Protein}-\text{Cu}^{+}{}_2+\text{O}_2 = \text{protein}-\text{Cu}_2-\text{O}_2 \quad (4)$$

$$\text{Protein}-\text{Cu}_2-\text{O}_2+\text{monophenol}+2\text{H}^{+} = \text{Protein}-\text{Cu}^{++}{}_2+o\text{-diphenol}+\text{H}_2\text{O} \quad (5)$$

$$\text{Protein}-\text{Cu}^{++}{}_2-+2e^{-} = \text{protein}-\text{Cu}^{+}{}_2 \quad (6)$$

$$\text{Protein}-\text{Cu}^{++}{}_2+o\text{-diphenol} = \text{protein}-\text{Cu}^{+}{}_2+o\text{-quinone}+2\text{H}^{+} \quad (7)$$

$$\text{Protein}-\text{Cu}_2-\text{O}_2+\text{monophenol} = \text{protein}-\text{Cu}^{+}{}_2+o\text{-quinone}+\text{H}_2\text{O} \quad (8)$$

This hypothesis explains the close association of catecholase with cresolase activity, and also provides a basis for the facile loss of cresolase activity during purification. The power of the oxygen complex, which we postulate as the cresolase-active site, to act as a locus of hydroxylation must depend upon the orientation of the electrons around the complex, and this in turn must depend upon the positions of the copper atoms relative to one another. Since the relevant valence states and bond angles are unknown, little can be said about this structure beyond the possibility that it may take one of the forms illustrated in Fig. 1, in which the positions of the copper atoms in the complex have been estimated from the structure of hydrogen peroxide[27]. Of the three configurations shown, one cis (*A*), one trans (*B*), and one containing a co-ordinated oxygen atom (*C*), the last is preferred for its asymmetry, which suggests a straightforward hydroxylation mechanism involving interaction of the oxygen atom with pi-electrons of the benzene ring. A change in the relative positions of, and the distance between, these two atoms of copper (3, 4, or 5 A.) must result not only in a change of oxygen-binding power but also of hydroxylating power, which will

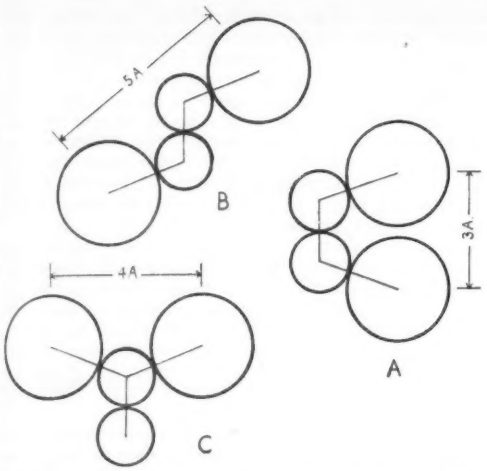

Fig. 1. Scale drawings depicting possible configurations of the cresolase-active copper–oxygen complex. The large circles represent copper atoms, the small circles, oxygen

therefore be sensitive to any small twist or spread of the protein backbone or amino-acid side-chains involved in the attachment of copper.

We designate this fixed, cresolase-active configuration 'closed phenolase'. Active enzymic sites which have been altered in respect to the positions of the copper atoms as a result of either physical or chemical influences we designate 'open phenolase'. The structural configuration of such a site may still exhibit much of its specificity towards substrate phenols, but may contain only one atom of copper either as a result of separation or loss of a mobile or loosely bound member of the pair. Since copper atoms attached to non-specific protein display pseudo-catecholase activity[28,29], there is no *a priori* reason for believing that the open configuration should have less catecholase activity than the closed structure. The ease with which the closed configuration is transformed into the open during purification may vary with the protein and its associated copper bonds, which are apparently of low stability in mushroom phenolase, of intermediate stability in potato phenolase, and are stable or protected in highly organized macrostructures such as mammalian melanin granules. The stability of cresolase activity must therefore bear a relationship to the characteristics of the aggregate upon which it occurs. Because of this sensitivity toward environmental changes, cresolase activity has resisted purification, and high-cresolase preparations resemble original extracts and differ from high-catecholase preparations in respect to solubility, copper content, behaviour towards adsorbents, and isoelectric *p*H, as well as in enzymic character.

Structure and Function

Elsewhere, oxygen transfer and electron transport by the phenolase complex have been related to the formation of the *o*-diphenolic precursors of the flavonoids, lignins, cuticulation diphenols of arthropods, etc.[30]. Although students of plant respiration have tended to lay emphasis on the catecholase aspect of the function of the phenolase complex, it follows from the present hypothesis that preparations of the high-catecholase type may be artificial in the sense that they bear a catalytic configuration which is produced in the process of isolation of the enzyme and which differs from that of the enzyme present within the cell. The high-cresolase (closed) form is the more nearly natural state of the enzyme. In this state a prevailing oxidation potential sufficiently high to keep the enzyme in the cupric form will prevent hydroxylation even in the presence of appropriate substrate and oxygen, but this inhibited phenolase complex may be activated by reduction. Thus, closed phenolase may occur *in vivo* as a reduced enzyme active towards both mono- and di-phenols, or as an oxidized form inert but activatable towards monophenols although already active towards *o*-diphenols. The open phenolase which is produced as a result of processes of purification is active towards *o*-diphenols but relatively inactive towards monophenols, which may act as substrate only owing to the residual closed form present in the enzyme preparation.

Finally, it is interesting to observe that the two series of metalloproteins involving hæm on one hand and copper on the other have striking similarities in their range of function. Each series contains an oxygen carrier dependent upon reduced metal (hæmoglobin and hæmocyanin), an electron carrier (cytochrome and catecholase), and an oxidizing enzyme (peroxidase and cresolase).

I wish to thank Sir Alexander Todd for the hospitality of his Department while this paper was being written. The United States Public Health Service and the American Cancer Society have supported this work.

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LETTERS TO THE EDITORS

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Measurements of Natural Freezing Nuclei at High Altitudes

A NUMBER of determinations of freezing nuclei has been made in aircraft. These form part of a programme of investigation into (*a*) the distribution and properties of freezing nuclei at high altitudes (where they are thought to play a part in the formation of rain by the Bergeron process), and (*b*) the question of whether the rainfall singularities reported by Bowen[1], and attributed by him to the arrival in the lower atmosphere of meteoritic dust, are accompanied by corresponding fluctuations in the concentration of freezing nuclei. Daily measurements were made near Sydney, Australia, during January 1954 and January 1955, and near Tucson, Arizona, United States, in January 1955. In addition, in January 1955 measurements using a somewhat similar method were carried out on a mountain top in the Hawaiian Islands. The results to date are summarized below. The month of January was chosen because the meteor dust – rainfall hypothesis was based on statistics for that month.

The airborne measurements at Sydney and Tucson were carried out as described by Smith and Heffernan[2], using cold chambers of 100-litres capacity. These were filled with air from outside the aircraft and cooled at 4 deg. C. per min., water vapour being added to form a fog. The concentration of ice crystals was observed at various temperatures, the threshold of detection being 0·1 crystal per litre. Samples were taken at various altitudes, but in this communication only results at altitudes exceeding 3,000 metres are given. On some days, two readings at the same altitude were made, and the mean is given.

Fig. 1 shows the daily variation in the warmest temperature at which one ice crystal per litre was observed, the three curves representing Sydney 1954 (full), Sydney 1955 (dashed) and Tucson 1955 (dotted). It can be seen that in both years this temperature varied markedly at Sydney, but much less at Tucson. The consistency of several readings on the same day is such that, while the temperature variation recorded at Tucson may not be significant, that recorded at Sydney is. If similar variations occur in the temperature of formation of ice crystals in natural supercooled clouds, then substantial differences in cloud behaviour should be observed on the corresponding days near Sydney but not near Tucson. The range of values recorded, from −16° C. to −33° C., appears to be consistent with the temperatures at which cumulus clouds are observed to glaciate.

Measurements in the Hawaiian Islands were taken at the top of the extinct volcano Haleakala on the island of Maui. It is 3,000 m. high and the top is nearly always above the trade wind inversion. Readings were taken at night in order to reduce the chance of sampling aerosols of local origin. A cloud chamber was used of a different design from those in the aircraft, and the measurements are not directly comparable. Its capacity was 50 litres. However, on certain days, namely, January 10, 23 and 29, the number of ice crystals observed at temperatures greater than − 25° C. was far larger than was the case on other days in January. These days are indicated on Fig. 1 by the letter *H*, all times being given as G.M.T.

Cwilong[3] has reported independent determinations of freezing nucleus in Panama using a small expansion chamber. Increases in the temperature at which effective nuclei were observed occurred on January 13, 18 and 31. These dates are indicated on Fig. 1 by the letter *P*. The dates on which fifty years total rainfall is abnormally high in Sydney are given by Bowen[1] as January 12–13, 22–23 and 31. These are indicated on Fig. 1 by the letter *R*.

If the rainfall singularities are associated with increases in concentration of freezing nuclei of cosmic origin, it might be expected that these various determinations of such nuclei would exhibit peaks at about the same time, and that the peaks would recur from year to year. It is therefore of interest to examine Fig. 1 from this point of view.

It can be seen that the two years measurements in Sydney do not agree well in the early part of January; but in the latter part of the month there are several features in common. The first rainfall peak, on January 12–13, coincides with peaks in the Sydney 1954 and 1955 curves, and with a peak at Panama. There is also a peak in Sydney (1954) on January 14. The second rainfall peak on January 22–23 again coincides with peaks in the Sydney 1954 and 1955 curves, and with a peak at Haleakala. The third rainfall peak, on January 31, coincides with a peak in Sydney (1954) and Panama, but peaks in Sydney (1955) and Haleakala occur two days before. The Panama peak of January 18 appears to be isolated.

It is not yet known what degree of consistency is to be expected from year to year and from place to place; and the present measurements, although not sufficient to confirm the theory, do show certain coincidences between rainfall singularities and peaks in the concentration of freezing nuclei at different geographical locations and at different times. It is hoped that the measurements can be continued in later years and in more places in order to help clarify

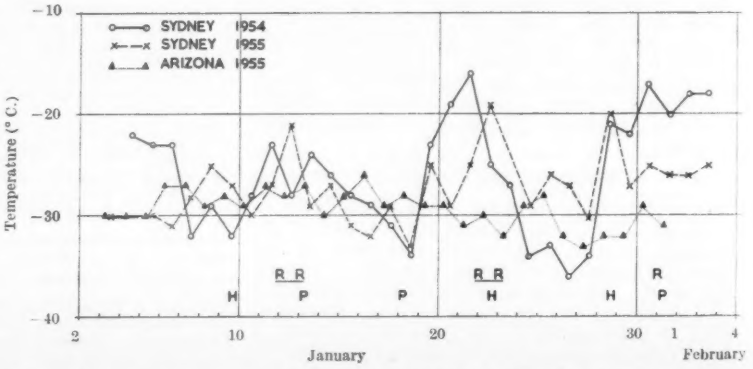

Fig. 1. Freezing nucleus measurements. Temperature at which one ice crystal per litre was observed

the question of whether there is a relationship between the concentration of freezing nuclei, meteor dust and the weather.

E. J. Smith
A. R. Kassander*
S. Twomey

Division of Radiophysics,
Commonwealth Scientific and
Industrial Research Organization,
Sydney, Australia. Aug. 31.

* Institute of Atmospheric Physics, University of Arizona, Tucson, Arizona.

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Electrolytic Desalting with Ion-Exchange Membranes

Separation of amino-acids and other substances by paper chromatography must often be preceded by the removal of inorganic salts. The common methods[1] require careful supervision, and under optimal conditions a loss of 10–20 per cent of many amino-acids may occur with 50 per cent loss of arginine by conversion to ornithine[2]. A simplified form of desalter, employing ion-exchange membranes, as suggested by Astrup and Stage[3], has been used in this Department for the routine preparation of plasma, urine and cerebrospinal fluid for paper chromatography. The apparatus consists of a small 'Perspex' container separated into three compartments by ion-exchange membranes (Fig. 1). The solution to be desalted in the centre compartment (3 ml.) is separated from the anode by an anion exchange membrane ('Permaplex' A.10) and from the cathode by a cation membrane ('Permaplex' C.10, both obtainable from Permutit, Ltd., London, W.4). The anode and cathode chambers are filled with 0·2 *N* sodium hydroxide and sulphuric acid respectively.

When a current is passed, the anion exchange membrane allows anions to move out of the centre compartment while preventing the ingress of cations,

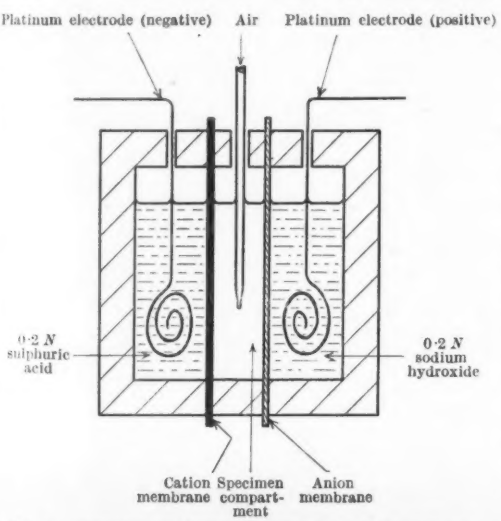

Fig. 1. Apparatus for electrolytic desalting with ion-exchange membranes

Table 1. Recoveries of Electrolytes and Amino-Nitrogen from Various Solutions after Desalting for 6 and 10 Minutes

Solution	Initial *p*H	Concentrations: Sodium (m.eq./litre) 0 6 10 (min.)	Chloride (m.eq./litre) 0 6 10 (min.)	Amino nitrogen (mgm. per cent) 0 6 10 (min.)
A. Salts + Glycine Alanine Phenylalanine Valine	7·2	126 55 37	100 52 29	5·6 5·3 4·8
B. Salts + Glycine Alanine Glutamic acid Arginine	7·3	124 56 22	103 49 31	6·0 5·8 4·6
C. Salts + Glutamic acid	7·2	127 49 30	100 50 27	6·2 4·2 4·3
Aspartic acid	4·4	125 53 28	100 45 30	6·2 4·9 4·4
D. Salts + Arginine	7·3	130 65 25	105 47 33	6·3 4·4 4·0
Lysine	8·8	130 60 20	105 53 30	6·3 5·3 5·0
Serum ultrafiltrate	7·1	139 40 19	—	10·9 9·0 7·0

and the cation membrane permits the passage of cations, but retains anions. The net result is a loss of electrolyte from the centre compartment with an increase in the salt concentration in the outer compartments. The current is supplied by a 6-V. accumulator, and a variable resistance (0–500 ohms) regulates the initial current to 50 m.amp.

Some loss of amino-acid is inevitable, and depends upon the dissociation of the various acids and also on the relative mobility of their ions. The rates of loss of the principal electrolytes of serum and of amino-acids were measured under standard conditions. A double-strength solution of plasma electrolytes was mixed with equal volumes of 0·01 *M* solutions of amino-acids, and desalted for 6 and 10 min.; the analytical results are shown in Table 1. The loss of neutral amino-acids was slight with an initial *p*H of 7·2 in the desalted solution. The greater losses of acidic and basic amino-acids could be reduced by bringing the initial *p*H nearer the *iso*electric point of the amino-acids concerned. Desalting of serum ultrafiltrates and casein hydrolysate solutions gave similar results.

A steep fall in current occurred after 6 min., when the salt concentration fell to about 30 per cent of its initial value; this level permits satisfactory separation on paper of amino-acids in serum, cerebrospinal fluid and concentrated urine samples. A fall in the *p*H of the solution during desalting occurs which increases the loss of basic amino-acids. This can be largely overcome by the addition of 0·1 *N* potassium carbonate to adjust the initial *p*H of the solution to 8·0. For routine chromatography of biological material for diagnostic purposes, neutralization of the samples is all that is necessary, since 25 per cent differences in concentration are the least that can be detected on paper.

J. D. Blainey
H. J. Yardley

Department of Experimental Pathology,
University of Birmingham. Sept. 7.

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Destruction of Thyroxine by Electrolytic Desalting

It is well known that artefacts and serious distortion can be caused during paper chromatography if acids are present in the solution being chromatographed, and that they can be eliminated by initial electrolytic desalting. In a recent communication[1], Acland confirmed that trichloracetic acid can be "largely" removed by desalting the solution electrolytically; as an example, he showed that the chromatographic picture from a mixture of thyroxine and trichloracetic acid was very distorted, whereas that from a mixture of thyroxine and 'desalted' trichloracetic acid was relatively undistorted.

It might therefore be supposed that electrolytic desalting of thyroxine extracts containing trichloracetic acid would improve their chromatographic investigation. We wish to point out that this is not the case, as the electrolytic desalting of thyroxine solutions leads to rapid reductive deiodination. After 10 mgm. of thyroxine, dissolved in 1 ml. of aqueous methanol containing trichloracetic acid or any other acid, had been subjected to electrolytic desalting at 500–250 m.amp. for 10 min., paper chromatography showed only thyronine to be present (ninhydrin reagent), with no detectable organically bound iodine (ceric sulphate – arsenite reagent, which would have shown as little as 1 per cent remaining[2]). Desalting for shorter periods (1 min.) gave intermediate products identified as various iodo-thyronines. When an aqueous solution of trichloracetic acid (1 ml. containing 10 mgm.) was desalted at 500–100 m.amp. for 7 min. its *p*H rose to 5·5, indicating virtually complete removal of the acid.

Further work on the stepwise dehalogenation of polyhalogen derivatives of tyrosine and thyronine will be reported elsewhere[3].

J. B. Jepson
I. Smith

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.
Nov. 1.

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Use of Gas–Liquid Partition Chromatography as a Preparative Method

The sharp separations obtainable by gas–liquid partition chomatography[1] would make it a useful alternative to distillation as a method for the purification of volatile compounds if the quality of the separations could be maintained on large columns. Evans and Tatlow[2] have described a column, 16 ft. long by 3 cm. internal diameter, which is suitable for the separation of 2–8 gm. of fluorocarbons. It is not yet clear, however, how much further the increase in size can be carried; but in any event, as so far developed, chromatography remains a batch process. Hence another line of approach to the problem of processing large amounts of material would be the automatic repetition of the cycle of batch operations, that is, injection of the charge and isolation of the pure material as it emerges from the column. This approach would be applicable whatever size columns are finally adopted.

Under fixed column conditions, each substance emerges at a constant time after injection, and this suggested that a clock might be used for controlling the cyclic process. We have constructed such a clock and used it successfully in the separation of C_4 hydrocarbon gases. In itself, the chromatographic apparatus is similar to those previously described, except that the column is somewhat larger (1 m. long by 15 mm. internal diameter) and two solenoid-operated valves are incorporated in the flow line. The gaseous sample is admitted to the column through one valve and the outlet gas can be deflected from one to another of two collecting traps by means of the other valve, which is located immediately after the detector[3]. The clock comprises a 'Londex' *PR/S* timer and a 50-position uniselector arranged to give a cycle of variable length divided into fifty equal intervals. At the beginning of each cycle, the inlet valve opens and a charge of the hydrocarbon gas is admitted to the column inlet, the amount depending on the pressure and the length of time the valve is open. The recorder trace for the detector is observed, and those positions of the uniselector corresponding to the peak required are wired together to operate the outlet valve and divert the flow of gas; in this way the wanted material is separated from the remainder. At a given column temperature the times of emergence of the component peaks can be varied by altering the rate of flow of the carrier gas which, together with the length of cycle, is arranged so that all the remaining components are eluted from the column before the next appearance of the peak required. So far, we have used cycles of 15–20 min. duration, (nitrogen) carrier-gas rates of about 30 l./hr. and a charge of somewhat less than 1 gm. (giving a daily throughput of between 70 and 80 gm.). Low-boiling materials prove difficult to remove from the carrier-gas stream, and it has been found most satisfactory to fill the collecting traps with activated alumina gel. In use they are immersed in a Dewar vessel containing solid carbon dioxide, and the gas can easily be recovered on warming.

The success of the method depends upon the pattern produced on the recorder remaining in phase with the clock. Such constancy in the times of emergence of the components of a mixture has been achieved in the trials so far carried out by attention to three factors: the temperature of the column (which was packed on ice), the rate of flow of the carrier gas, and its presaturation with the solvent used. In these conditions successful runs, lasting several days, have resulted in the expected separation and no adjustments to the clock have been required.

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D. Ambrose
R. R. Collerson

Chemical Research Laboratory,
Teddington, Middlesex.
Oct. 28.

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Determination of Chromium, Vanadium and Tungsten by Activation Analysis using Low-Level Neutron Sources

A RADIOCHEMICAL method for the determination of chromium, vanadium and tungsten by means of radioactive silver was suggested by J. Govaerts[1]. Insoluble silver salts can be prepared by means of these elements. Using a solution of radioactive silver nitrate, a standard curve is obtained indicating the activity of the precipitate as a function of the quantity of metal present. The purpose of the present work was to use the same silver salts in order to determine the amount of element present by means of thermal neutron activation of silver ($T_{\frac{1}{2}} = 22$ sec. and 2·3 min.), which quantity is proportional to that of the unknown element.

Preliminary investigations indicated that chromium and tungsten are not activated by a thermal neutron source of 270 mgm. radium–beryllium when exposed during 10 min. Under the same conditions, vanadium is fairly well activated ($T_{\frac{1}{2}} = 4·5$ min.) and this activity adds to that of silver. Up to 25 mgm./cm.^{2}, no corrections for self-absorption are required for either of the three insoluble silver salts.

By means of a neutral solution of silver nitrate, chromium is precipitated as silver chromate[2], vanadium as silver vanadate[3] and tungsten as silver tungstate[4]. A Geiger–Müller tube with thin mica window is used for the measurements of radioactivity. The compounds are collected in a uniform and reproducible manner. One of the techniques used is similar to that described by R. H. Hendricks *et al.*[5] for mounting barium-14 carbonate on a flat circular disk of aluminium by gravity settling, except that we have used 'Plexiglas' plates, which are not activated by neutrons. A demountable centrifuge tube can also be used[6]. With certain precautions the precipitate can be collected quantitatively. Using different amounts of silver salts, standard curves are obtained indicating the activity of the precipitate as a function of the quantity of the metal present (Fig. 1). The procedure to determine an unknown concentration is to collect the precipitate on a fritted-glass filter; the precipitate is dried and weighed. The total precipitate, or a known aliquot part, is then collected on a 'Plexiglas' plate and activated; the same geometrical conditions are used for all radioactivity measurements. The amount of the element present on the plate is read on the standard curve.

The method described is very quick, sensitive and well suited to routine use.

I wish to thank Prof. G. Gueben for the opportunity of working in the Institute of Nuclear Studies, Liège, and Prof. J. Govaerts for his interest.

M. HUARINGA*

Institute of Nuclear Studies,
University of Liège.
Sept. 6.

* On leave from the San Marcos University of Lima.

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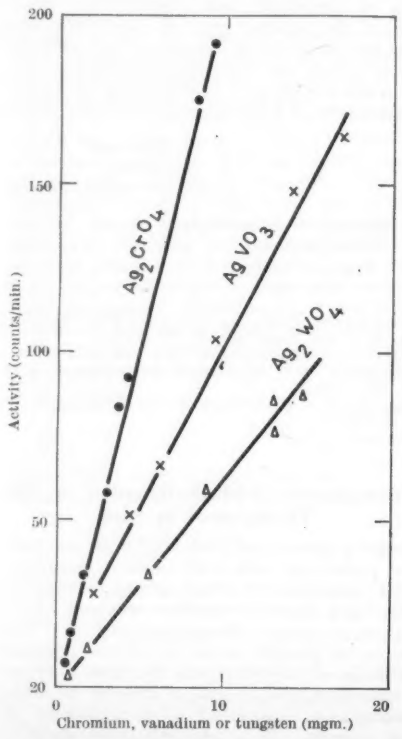

Fig. 1

Infra-Red Absorption Spectra and Protein-Sugar Interactions

BIOLOGICAL materials consisting largely of protein and carbohydrate give rise to infra-red absorption spectra which show the main characteristic absorption bands of the protein and carbohydrate structures. A more detailed study of the spectra of such biological materials reveals a number of important differences from the spectra expected by the direct addition of the typical protein and carbohydrate spectra, and these differences confirm the suggested interaction of the protein with the carbohydrate.

The infra-red spectra of most sugars show a series of sharp absorption bands in the 1,050 cm.$^{-1}$ region[1], similar to those shown in spectrum *A* (Fig. 1). In biological materials containing sugar these sharp bands are replaced by bands of much broader structure, similar to those shown in spectrum *B*. Such broad bands can be observed in the published infra-red spectra of bacteria[2] and tissues[3], and also in unpublished spectra obtained from dried milk and freeze-dried bovine uterine cervical secretions.

This protein–sugar interaction and its effects upon the infra-red spectra can be demonstrated by the spectra of casein and lactose shown in Fig. 1. Spectrum *A* was obtained from a dry intimate mixture of casein (soluble, commercial product) and lactose (freeze-dried monohydrate) made up in the same proportions as are present in cow's milk, that is, approximately 3 parts by weight of casein to 5 parts of lactose. Spectrum *B* was obtained by dissolving the same mixture in water at room temperature and then freeze-drying. Similar results have been obtained for casein–glucose and casein–sucrose mixtures.

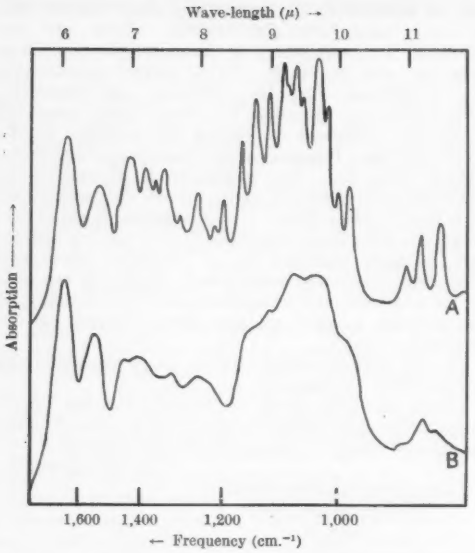

Fig. 1. *A*, lactose–casein dry mixture; *B*, lactose–casein, freeze dried from aqueous solution

It is probable that this interaction of casein with sugars forms the first stage in the series of reactions studied by Lea and his co-workers[4] in relation to the browning of milk.

Since the carbohydrate absorption bands in the 1,050 cm.$^{-1}$ region are generally associated with the C—O stretching and the O—H bending vibrations, it seems likely that the carbohydrate and protein molecules are held together by a hydrogen-bonding mechanism. Such interaction would be expected to affect the carbohydrate bands in this region of the spectrum as well as in the more usually studied 3μ region.

The spectra were obtained with a double-beam Grubb Parsons *S3A* infra-red spectrometer fitted with a rocksalt prism. Samples were examined in potassium bromide disks, and similar results were also obtained using the 'Nujol' mull technique with the same samples.

J. D. S. Goulden

Physics Department,
National Institute for Research in Dairying,
University of Reading.
Aug. 29.

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Separation of the Isomers of Benzene Hexachloride by Reversed-Phase Paper-Partition Chromatography

A simple and rapid paper chromatographic method was required for separating mixtures of isomers of benzene hexachloride. The paper chromatographic method of Moynihan and O'Colla[1], further developed by O'Colla[2] and Mitchell[3], gives a satisfactory separation, but the acetic anhydride, used as the stationary phase, is an unpleasant reagent to handle. The use of 'Vaseline'-impregnated strips has been previously described for the separation of DDT derivatives[4], and there was some evidence that separation of isomers of benzene hexachloride could be achieved by the application of a similar technique[5]. The method has been adapted as follows.

Whatman No. 1 filter paper strips were washed overnight by allowing distilled water to travel down the strips as in chromatography in order to remove an inorganic halide contaminant present in the paper. The strips were then dried, dipped in a 5 per cent ethereal solution (w/v) of Paraffinum Molle Album, drained and dried. The mixture of the isomers in acetone solution was applied as a small spot near the top of a strip. The mobile phase, consisting, by volume, of 70 per cent methanol and 30 per cent distilled water, was allowed to descend the strip in the normal way. The strip was left at laboratory temperature for 18 hr., during which time the solvent had travelled approximately 40 cm.

The strip was dried and the positions of the isomers detected by dipping it in redistilled monoethanolamine, heating at 100° for ½ hr. and then dipping in a 0·1 *N* solution of silver nitrate acidified with concentrated nitric acid (10 vol. silver nitrate solution : 1 vol. acid). On exposure to ultra-violet light (*c.* 254 mμ) brown spots appeared corresponding to the positions of the isomers. It was essential to remove all the monoethanolamine before dipping in silver nitrate solution, otherwise a background colour developed which masked the spots. The alpha-, beta-, gamma- and delta-isomers moved with mean R_F values of 0·33, 0·00, 0·40 and 0·58 respectively. The method of detection was sensitive to less than 5 μgm. of the alpha-, gamma- and delta-isomers, but was less sensitive in the case of the beta-isomer, 5 μgm. of which was only just detectable.

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R. G. Bridges
A. Harrison
F. P. W. Winteringham

Pest Infestation Laboratory,
London Road,
Slough, Bucks.
Oct. 20.

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η-Tocopherol (7-Methyltocol): a New Tocopherol in Rice

Recent publications have confirmed the existence of two previously unknown natural tocopherols in the lipid fractions of cereal grains (ε- and ζ-tocopherols) and have described methods for their separation by paper chromatography[1–3]. Thus six of the seven possible tocol structures produced by methylation of the tocopherol chroman nucleus have been identified, and it was of interest to search for the remaining tocopherol (7-methyltocol) among natural sources. In a comprehensive study of the vitamin E content of various foodstuffs, Harris,

Quaife and Swanson[4] reported some years ago that 50 per cent of the total tocopherols in rice were γ- and δ-tocopherols. These authors used the diazo-coupling method of analysis[5] for this identification. Since this observation conflicted with our own observations on tocopherol patterns in cereal products, we have re-investigated the vitamin E content of rice.

The lipid fraction was extracted with ether from ground whole Japanese rice. After the usual purification by alkaline saponification and treatment with floridin earth, the vitamin E complex was analysed by two-dimensional chromatography[2]. The papers, after spraying with ferric chloride – dipyridyl reagent in ethanol, showed three well-defined spots in the α-, ε- and ζ-positions; γ- and δ-tocopherols were absent. However, the spot in the ε-position, on spraying with diazotized *o*-dianisidine in alkaline solution, showed a strong positive reaction, given only with tocopherols having a free, non-methylated 5-position. The known ε-tocopherol does not react with this reagent, and, by methods of separation to be described elsewhere, it was shown that rice contains little or no ε-tocopherol. From its chromatographic behaviour (which assigns it the structure of a monomethylated tocopherol) and reaction with the *o*-dianisidine reagent, therefore, the new spot was considered to be due to 7-methyltocol, which, according to custom, has been named η-tocopherol. Rice contains α-, ζ- and η-tocopherols in the proportion 47 : 26 : 27.

Extraction of 200 gm. of whole rice followed by saponification of the oil, chromatography and isolation by two-dimensional paper chromatography on multiple papers by methods already described[2] gave nearly 3 mgm. of almost pure η-tocopherol. The new tocopherol could be assayed normally with the Emmerie–Engel reagent and coupled immediately with the *o*-dianisidine reagent. It had an absorption maximum at 293 mμ (*E*(1 per cent, 1 cm.), 78) and gave a yellow nitroso derivative with nitrous acid. Oxidation with nitric acid, according to Smith *et al.*[6], gave the red *o*-quinone, with absorption maximum at 477 mμ (*E*(1 per cent, 1 cm.), 56). The identity of η-tocopherol with 7-methyltocol was finally confirmed by direct methylation on 1 mgm. of the substance by reaction with formaldehyde, hydrochloric acid and stannous chloride[7]. The methylated product, on two-dimensional paper chromatography, gave two new spots, identified by R and R_F values and chemical tests as α- and ζ-tocopherols.

All seven possible tocopherols with methyl groups in the chroman nucleus have now been shown to occur in Nature.

J. Green
S. Marcinkiewicz

Walton Oaks Experimental Station,
Research Laboratories of Vitamins, Ltd.,
Dorking Road,
Tadworth, Surrey.
Nov. 11.

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Thermodynamic Aspects of the Action of Phosphohexoseisomerase

The isomerization of glucose-6-phosphate ⇄ fructose-6-phosphate is catalysed by the enzyme phosphohexoseisomerase[1], and at equilibrium a mixture of aldose and ketose in the proportion of 6/4 is present[2,3]. Although Bruns and Hinsberg[3] have investigated the kinetics of this isomerase system by the method which was also employed in the present experiments, the thermodynamic properties of this reaction have not been studied.

The free-energy change and activation-energy change of the isomerization process can be calculated from earlier data concerning the effect of temperature on reaction velocity. From the equilibrium constant K calculated from the molar concentration of the reactants,

$$K = \frac{[\text{Glucose-6-phosphate}]}{[\text{Fructose-6-phosphate}]} \qquad (1)$$

the free-energy change of -84 cal. mole^{-1} was obtained based on the equation

$$\Delta F^{\circ} = -RT \ln K \qquad (2)$$

The reaction kinetics are of pseudo zero order in the presence of an excess of glucose-6-phosphate and may be formulated in the following way,

$$v_i = k_1 E S_0 \qquad (3)$$

where v_i is initial reaction velocity, S_0 is initial concentration of substrate, E is enzyme concentration and k_1 is reaction constant.

If k_1 is expressed in terms of the Arrhenius equation[4,5],

$$k_1 = PZ \exp(-\Delta E/RT) \qquad (4)$$

then, from earlier results[1] when v_i was studied as a function of T over the range 23°–40° C., log v_i is proportional to $1/T$, and the activation energy, ΔE, can be evaluated as $-11{\cdot}3$ kcal./mole^{-1}.

When Eyring's equation[5],

$$k_1 = \frac{kT}{h} \exp\left(-\frac{\Delta H^*}{RT}\right) \exp\left(\frac{\Delta S^*}{R}\right) \qquad (5)$$

is applied, ΔH^*, the heat of activation, can be estimated. From the proportionality of log v_i/T to $1/T$, ΔH^* (10·4 kcal./mole) also can be evaluated using the slope of a plot of log v_i/T versus $1/T$. A diagram demonstrating the energy relationship of this reaction is shown in Fig. 1.

The activation energy can be estimated from bond energies. If we assume the following 'activated

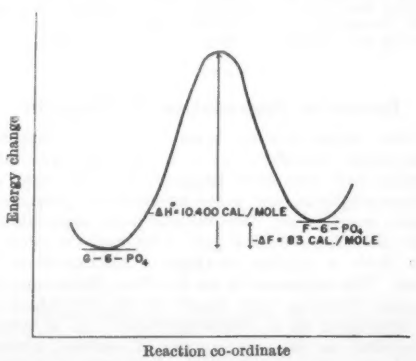
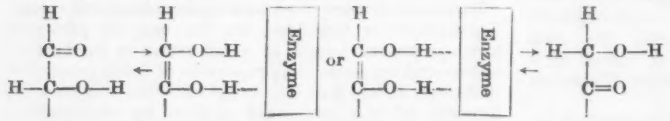


Fig. 1

complexes' of the hypothetical intermediary ene–diols with the isomerase,



the differences of the bond energies[6] in the activated complexes as compared with glucose-6-phosphate or fructose-6-phosphate are about − 9 kcal./mole or − 14 kcal./mole, respectively. In this estimate the energy of formation of the hydrogen bond is assumed to be 5 kcal./mole. Although the exact structure of the 'activated complex' is unknown, the activation energy estimated on the basis of the above structure is in reasonably good agreement with the values calculated from kinetic experiments. Since the activation energies based on other possible structures of the activated complexes deviate considerably from those obtained from the experimental observations, the structure of the 'activated complex' proposed above does not seem unreasonable. Such a postulated complex in the isomerase system should have an activation energy of about 10 kcal./mole. This excludes complexes with a saturated C—C bond or those involving electrostatic forces between oxygen and the enzyme.

The linear relationship of log v_i to $1/T$ holds at higher temperature, and therefore ΔE of denaturation by heat may be calculated from equation (4). As a result, a value of 26·8 kcal./mole is obtained, which is of an order comparable with that reported for heat denaturation of other enzymes[7].

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F. Bruns*
S. Okada

Department of Experimental Radiology,
University of Rochester
School of Medicine and Dentistry,
Rochester, New York.

Aug. 4.

* Max Kade Fellow. Present address: Physiologisch-Chemisches Institut der Medizinischen Akademie, Düsseldorf.

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Bacterial Degradation of Heparin

A soil bacterium has been isolated in pure form by repeated transfers on a liquid medium which contained 0·1 per cent heparin, 0·1 per cent ammonium sulphate, and trace amounts of magnesium, calcium, manganese, ferrous iron and molybdate in 0·1 *M* phosphate buffer (*p*H 7·4) and on silica gel plates with a similar medium evaporated on the surface. The organism is an aerobic, Gram-negative, non-spore forming, very small, motile rod which had been identified as a *Flavobacterium*. It is able to use heparin as its sole source of carbon, nitrogen and sulphur, although its growth is enhanced by the addition of small amounts of glucose and ammonium sulphate. Optimum growth occurs at *p*H 6·5 and 24°; the bacterium will not grow at 37° and its growth is inhibited by carbon dioxide and agar (when grown on heparin). When grown on heparin silica gel plates the bacteria form clear, lemon-yellow, round, microscopic colonies; on trypticase–phytone agar plates the colonies are larger and dark orange-yellow in colour.

Due to its high cost, heparin cannot be used as substrate for large-scale bacterial preparations. In order to obtain cells in large quantity, the bacteria were cultured on a medium which consisted of 1·7 per cent trypticase, 0·3 per cent phytone, 0·25 per cent glucose, 0·5 per cent sodium chloride and 0·25 per cent dipotassium hydrogen phosphate in tap water. The cells were harvested after two weeks and washed free of medium with 0·1 *M* phosphate buffer (*p*H 7·4). They were then adapted to heparin by the following procedure. A thick suspension of washed cells was aerated at 24° for a starvation period of 2 hr. Heparin (35 mgm. per 100 ml.), casein hydrolysate (50 mgm. per 100 ml.) and yeast extract (5 mgm. per 100 ml.) were added and the aeration continued. Adaptation occurred within three hours (the adaptation period was halted when 50 per cent of the heparin had disappeared). The cells were collected, washed with distilled water, lyophilized and stored in a vacuum desiccator at − 20°.

Dried cells prepared in this manner metabolized heparin both aerobically and anaerobically. In both instances, as was also the case for growth and adaptation of the organism, the reaction proceeded optimally at 24° and not at all at 37°. The disappearance of heparin was more rapid under anaerobic conditions. The dried cells appear able to degrade heparin by

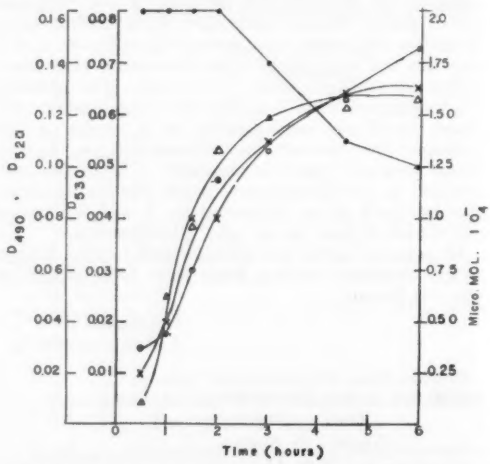

Fig. 1. Accumulation of reaction products during the degradation of heparin by dried cells. The incubation vessels contained 2 mgm. of heparin and 5 mgm. of dried cells in 2·5 ml. of 0·1 *M* phosphate buffer, *p*H 7·4. The vessels were incubated at 24° in an atmosphere of nitrogen–carbon dioxide (95 : 5). At each of the times indicated one vessel was removed and analysed for heparin (ref. 1) ●, reducing groups (ref. 2) ×, periodate titratable groups (ref. 3) △, and glucosamine (ref. 4) ○. Heparin determinations were performed on aliquots of 0·02 ml., reducing groups on aliquots of 0·01 ml., periodate titrations on aliquots of 0·1 ml., and glucosamine on aliquots of 0·2 ml. Values obtained in control vessels in which dried cells were incubated without heparin have been subtracted in all cases

two different mechanisms. Thus, aerobically, heparin was degraded more rapidly at *p*H 6·5 than at 8·5, whereas anaerobically the reverse was true. In preliminary experiments with borate buffer under aerobic conditions, heparin was degraded more rapidly at *p*H 8·5 than at 6·5. There may, then, be one reaction sequence (with optimum *p*H 6·5) which requires both oxygen and phosphate, and another (with optimum *p*H 8·5) which functions in the absence of either oxygen or phosphate.

In preliminary experiments with wet cell suspensions of the adapted bacteria, it was found that neither acids nor carbon dioxide are formed during the anaerobic metabolism of heparin. When heparin was incubated anaerobically with dried cells, reducing groups, periodate titratable groups and glucosamine were formed (Fig. 1). The appearance of these reaction products before detectable disappearance of metachromasia indicates the accumulation of intermediates which, while no longer identical with 'native' heparin, are still metachromatic. The isolation and identification of such intermediates should help elucidate the fine structure of heparin.

We are indebted to Dr. C. B. Anfinsen, who suggested this approach. Sodium heparin (117 units/mgm.) was obtained through the kindness of Dr. L. L. Coleman, of the Upjohn Company, Kalamazoo, Michigan. One of us (A. N. P.) is a participant in the Foreign Research Science Program of the Foreign Operations Administration.

A. Nail Payza
Edward D. Korn
Laboratory of Cellular Physiology and Metabolism,
National Heart Institute,
National Institutes of Health,
Department of Health, Education and Welfare,
Bethesda 14, Maryland.
Aug. 29.

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Uptake of Adenine-8-^{14}C by Whole and Fractional Amœbæ

Recently, Goldstein and Plaut[1] have obtained direct evidence for the synthesis of cytoplasmic ribonucleic acid by the nucleus in *Amoeba proteus*. The demonstration by Brachet and Szafarz[2] that enucleate fragments of the unicellular alga *Acetabularia mediterranea* exhibit a distinct turnover of a precursor of ribonucleic acid (orotic acid) has been interpreted by Brachet[3] as indicative of cytoplasmic synthesis of ribonucleic acid in the absence of a nucleus. If these two findings are both applicable to cells in general, we could conclude that there are two basic systems of synthesis of cytoplasmic ribonucleic acid : one centred in the nucleus, and the other a cytoplasmic system which is independent of the nucleus. In order to investigate this possibility, we have undertaken a study of the incorporation of the ribonucleic acid precursor adenine-8-^{14}C into whole and fractional amœbæ. For a valid comparison of the rates of synthesis of cellular constituents it is necessary, first of all, to ascertain the intracellular availability for synthesis of a labelled precursor in whole and nucleate and enucleate half-cells[4]; otherwise an impaired ability to transfer a material across the cell membrane might be mistaken for a reduction or loss of synthetic capacity.

Table 1. Uptake of Adenine-8-^{14}C by Whole (*W*), Nucleate Half (*N*) and Enucleate Half (*E*) Amœbæ

		Incubation time (hr.) 18		43		51	
Counts/min./amœba (No. of cells in sample in parenthesis)	*W*	1·06 1·02	(25) (24)	2·66 2·71	(50) (60)	3·24	(25)
	N	0·69 0·88	(25) (17)	2·12 2·03	(50) (43)	2·58	(22)
	E	0·38 0·35	(19) (24)	1·10 0·90	(50) (60)	1·65	(11)
Ratios	*W*/*N*	1·32		1·30		1·26	
	N/*E*	2·15		2·08		1·56	

Counts are corrected for a background based on samples of the last wash-water, which never differed significantly from the general background : 11–12 counts per min.

Amœbæ (*A. proteus*) were cultured for 24-hr. in food-free medium. Some of them were then cut, free-hand, with a fine glass needle into nucleate and enucleate halves. After separation of the nucleate and enucleate halves, the cells, including a sample of whole amœbæ, were washed twice to remove possible debris and transferred to a food-free medium containing 1·7 μc. of adenine-8-^{14}C per ml. (0·13 mgm. per ml.). This ribonucleic acid precursor was chosen since experience in our laboratory has shown that it is readily incorporated into ribonucleic acid by amœbæ[5]. During the incubation period, samples of all three experimental groups were withdrawn at different times, dried on planchets after sufficient washing in inactive medium to remove external isotope, and assayed in a windowless gas-flow counter.

Taking the volume of an average whole amœba[6] as $8 \times 10^5\ \mu^3$ and that of a half amœba as $4 \times 10^5\ \mu^3$, we obtain, for equivalent volumes of labelled medium, an activity of about one count per minute corresponding to the whole cell and 0·5 count per minute for the half-cell. It can be seen from Table 1 that the measured activity of the cells and the half-cells reaches a higher level. From this comparison and from the evident linearity of the curves in Fig. 1,

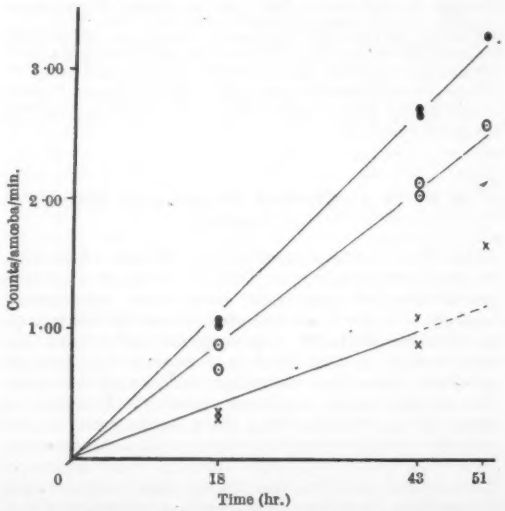

Fig. 1. ● Whole cells; ⊙ nucleate halves; × enucleate halves

we conclude that there is a continuous uptake of adenine-8-^{14}C and not a passive equilibration of cells with the medium.

Our results indicate that, as with other substances[7], the presence of the nucleus is not essential for the uptake of adenine. However, the ratio of 1·3 : 1 between whole amœbæ and nucleate halves shows that a doubling of the amount of cytoplasm increases the uptake by only 30 per cent. This fact, together with the distinctly higher ratio of 2·1 : 1 between nucleate halves and enucleate halves, demonstrates the importance of the nucleus in adenine uptake during the early incubation period. The value of the 51-hr. point for enucleate half amœbæ is questionable, because of the small size of the sample; but it is being rechecked in a series of experiments designed to elucidate the uptake and incorporation pattern of adenine over a longer period of time.

There are at least two possible interpretations for the higher activity within the cell than outside it; a mechanism may be in operation for the active uptake of adenine against a concentration gradient, or the intracellular adenine may be converted into other products. Whatever the reason, the fact that adenine enters the enucleate half-cell demonstrates its intracellular availability for incorporation or conversion processes if such processes take place.

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Walter Plaut
Ronald C. Rustad

Department of Zoology,
University of California,
Berkeley, California.
Aug. 26.

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A Virus in Chronic Respiratory Disease of Turkeys

In the chronic respiratory disease syndrome of chickens and ducks, both a virus and pleuropneumonia-like organisms have been etiologically implicated[1]. Serological studies on infectious sinusitis of turkeys, utilizing a hæmagglutination-inhibition test, indicated that there is a relationship between presence of antibodies against the pleuropneumonia-like organisms and a clinical sinusitis[2]. However, in some birds, infection with the pleuropneumonia-like organisms did not result in development of a sinusitis. Observations on field-outbreaks of chronic respiratory disease and their relation to the onset and severity of sinusitis in turkey flocks seemed to indicate that the pleuropneumonia-like organisms did not serve to define the etiology of these syndromes. This became apparent in two outbreaks when it was demonstrated that a large percentage of the birds were serologically positive to the pleuropneumonia-like organisms prior to the onset of respiratory symptoms, and furthermore that sinusitis was observed in only 2–5 per cent of the birds. Within two weeks after the onset of the respiratory symptoms, 40 per cent of the birds in one flock and 60 per cent of the birds in the other flock developed sinusitis.

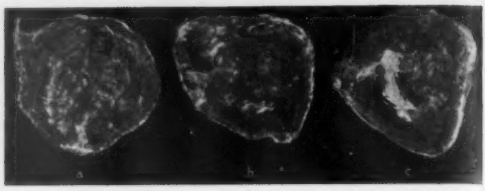

Fig. 1. Pocks on eleven-day old chorioallantoic membranes produced by viruses isolated from (*a*) chickens, (*b*) ducks and (*c*) turkeys infected with chronic respiratory disease

During the acute stage of the respiratory disease, turkeys from both outbreaks were killed, and attempts to isolate a virus were made by procedures which have proved practical for isolating viruses from similar clinical conditions in other fowl[1]. An agent which showed filterability, resistance to antibiotics and inability to be demonstrated with a variety of stains under the light microscope was isolated from both outbreaks. This agent, which is tentatively presumed to be a virus, grew in the yolk sac and chorioallantoic sac of chicken embryos and produced pocks on the chorioallantoic membrane. Specific embryo deaths followed inoculation into the chorioallantoic sac in 24–48 hr. and maximal pock production was observed on the chorioallantoic membrane in 72 hr. Fig. 1 compares the pocks produced by one of the turkey strains with those of chicken and duck strains of a virus with similar properties. It should be emphasized that this agent was not a pleuropneumonia-like organism, although these organisms were also isolated from the infected flocks. Another strain of the virus was isolated from a flock of turkeys experiencing a mild and transient respiratory disease. This isolation was of interest since the turkeys were free of infection with the pleuropneumonia-like organism, and infection with the virus did not result in sinusitis in any of the birds.

In an effort to identify this virus, serum neutralization tests were carried out in either the chorioallantoic sac or on the chorioallantoic membrane, using sera containing antibodies against infectious bronchitis, Newcastle disease and infectious laryngotracheitis viruses. No neutralization of the turkey virus could be demonstrated in any case, nor would sera from birds inoculated with the turkey virus neutralize any of the above viruses. This would seem to exclude the possibility that this new virus bears a *P–Q* relationship to infectious laryngotracheitis, since in Pulsford's work the *Q* variant produced antibodies fully active against laryngotracheitis virus[3].

The findings of a virus in chronic respiratory disease of turkeys with characteristics identical with those isolated from chickens and ducks would seem to indicate a common etiological factor in these syndromes. Proof of this contention, however, must await serological and cross-infection studies. The exact relation of this virus to the onset and incidence of sinusitis in turkeys infected with the pleuro-

pneumonia-like organism similarly remains to be determined.

J. E. FAHEY

Connaught Medical Research Laboratories,
University of Toronto.
Aug. 29.

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Abnormal Colour Responses of the Minnow resulting from Inhibition of Movement

WHEN a minnow (*Phoxinus phoxinus* L.) is allowed to swim freely on an illuminated white or black background, it becomes correspondingly pale or dark in colour and remains so indefinitely. However, if the fish is kept stationary by confining it on a white or black background in a glass tube containing running aerated water, its colour responses become abnormal[1].

During the first hour or so of confinement, the fish struggles; but later, escape reactions cease and the fish remains quiescent on the floor of the tube. Under these conditions on either a white or a black background the fish fails to become fully white- or black-adapted; it assumes an intermediate tint and maintains this indefinitely. However, if the fish confined on black is subjected to an extraneous stimulus, for example, a movement in its field of vision, sudden alteration of the rate of flow of water in the tube or change in hydrostatic pressure, it will suddenly become fully dark in tint and then in the following 15 min. slowly revert to the intermediate colour. In other words, an extraneous stimulus momentarily converts an abnormal black background response to a normal one. No response to an extraneous stimulus in a fish confined on white has been observed; the fish remains an intermediate tint.

The minnow melanophores are under the control of both nerves and pituitary hormones, and spinal section anterior to the fifteenth vertebra eliminates central nervous control, resulting in very slow background responses effected by hormones[2]. Confinement on black does not interfere with the slow darkening of such a spinal fish, and an extraneous stimulus never results in a momentary darkening. Similarly, when central nervous control is eliminated only from the anterior region of the body by sympathectomy and the fish confined on black, this region slowly becomes fully dark, while the posterior region remains intermediate in colour. In this case an extraneous stimulus results in a momentary darkening of the posterior body region, but has no effect on the anterior region. On the other hand, hypophysectomized fish confined on black maintain an intermediate tint and show a darkening response to an extraneous stimulus. Therefore, the abnormal tint caused by confinement appears to be due to interference with the nervous rather than the hormonal chromatic mechanism.

In an unrestricted environment the minnow is an extremely active fish. Confinement thus abolishes continuous somatic motor activities, imposing a learnt inhibition on the central nervous system. It seems probable that this inhibition becomes generalized and affects the brain centres controlling colour change. An extraneous stimulus appears to remove temporarily the central inhibition, permitting for a time a normal black-background response.

The abnormal response resulting from confinement on white is less easy to explain. Under these conditions normal, spinal and hypophysectomized fish alike remain intermediate in colour and show no reaction to an extraneous stimulus. Both nervous and hormonal mechanisms appear to become abnormal under these conditions, and the absence of a sudden paling in response to an extraneous stimulus in the case of normal or hypophysectomized fish remains at present unexplained.

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E. G. GRAY

Department of Anatomy,
University College,
London, W.C.1.
Aug. 29.

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Role of Ergothioneine and Catalase in Infection by Ergot Fungus (*Claviceps purpurea* Tul.)

I HAVE already shown that the activity of peroxidase and catalase in rye is altered by ergot infection[1]. It seems to be very probable that this circumstance indicates formation of peroxide in the host-plant. The present communication deals with the effect of hydrogen peroxide on germination of ergot conidia.

Ergot was cultivated on malt agar. Conidia of a culture 3–5 weeks old were germinated at 20–22° C. in hanging drops on a culture medium of the composition: KH_2PO_4 1·0 gm., $MgSO_4.7H_2O$ 0·6 gm., $CaCl_2$ 0·5 gm., asparagine 2·0 gm., saccharose 30·0 gm., distilled water 1 litre. To this culture medium was added hydrogen peroxide, ergothioneine and the centrifuged conidia-free substances of honey-dew.

We have found that hydrogen peroxide in a concentration of 5×10^{-3} *M* entirely inhibits the germination of conidia. This inhibition can be removed by 5×10^{-3} *M* ergothioneine. Ergothioneine by itself has no effect on germination. We were unable to demonstrate ergothioneine in saprophytic conidia by the Hunter diazo-reaction[2].

It is known that conidia of parasitic origin (honey-dew) are more aggressive than saprophytic ones[3]. Honey-dew was gathered from Petkus rye; it was diluted with water in the ratio of 1 : 50, then centrifuged and examined for ergothioneine. We were able to prove that the conidia do not contain ergothioneine; on the other hand, ergothioneine was present in the conidia-free substances of honey-dew. The conidia-free sap from 50 million conidia (about 0·1 ml. honey-dew) contains 0·2–0·5 mgm. ergothioneine. It should be noted that another substance present also gives the diazo-reaction; this substance shows a maximum absorption at 6300–7000 A. At the same time, we have also found that the catalase activity of washed honey-dew conidia and saprophytic conidia was weak. During 5 min., 0·27–0·85 mgm. hydrogen peroxide was decomposed *in vitro*. Honey-dew sap shows a high catalase activity; during 5 min., 4·54 mgm. hydrogen peroxide was destroyed.

When honey-dew sap was added to saprophytic conidia, a weak stimulation of germination and an

Table 1. Inhibiting Effect of Hydrogen Peroxide on Germination of Ergot Conidia of Saprophytic Origin (per cent) and on Growth of Germ Hyphæ (Micra); Elimination of Inhibiting Effects by Ergothioneine and by Honey-Dew Sap

Culture medium + inhibitor and protector	Conidia germinated during 24 hr. No. (per cent)	Length (μ)
5×10^{-2} *M* hydrogen peroxide	0	0
5×10^{-2} *M* ergothioneine	15	110
5×10^{-2} *M* ergothioneine + 5×10^{-2} *M* hydrogen peroxide	13	90
1 : 50 diluted honey-dew sap	24	325
1 : 50 diluted honey-dew sap + 5×10^{-2} *M* hydrogen peroxide	22	325
Control	17	105

intense stimulation of growth was observed. No toxic effect of hydrogen peroxide was found in the presence of honey-dew sap (see Table 1).

These results indicate that honey-dew contains certain substances which are stimulating and certain which are protective against hydrogen peroxide. Among the protective substances there are ergothioneine and catalase, which may at least partially account for the fact that honey-dew conidia are more aggressive than conidia of saprophytic origin[3].

I am indebted to Prof. G. Hunter for help in this investigation. It is proposed to publish fuller results elsewhere.

A. St. Garay
Research Institute for Medicinal Plants,
Dániel-ut 40,
Budapest, XII.

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A Lysogenic Strain of *Rhizobium trifolii*

During the course of routine examination of strain *SU*298 (Sydney University strain) of *Rhizobium trifolii*, it was suspected that the strain was carrying a bacteriophage. Subsequent investigation proved strain *SU*298 to be lysogenic, and the closely related strain *SU*297 to be a susceptible indicator strain. The field-performances and relationships of these strains have recently been reviewed by Vincent[1]. The occurrence of lysogeny in *SU*298 was demonstrated by seeding yeast mannitol agar (0·4 per cent agar) with appropriate proportions of each strain and incubating the plates at 26° C. After 24–48 hr., plaques could be observed in the otherwise confluent growth of *SU*297. At the centre of each plaque was a colony of the lysogenic strain. The lysogenic nature of strain *SU*298 was confirmed by the fact that it proved to be resistant to the purified phage; strain *SU*297, on the other hand, was fully susceptible.

A series of colonial variants of strain *SU*298, the characteristics of which have been described in detail by Vincent[1], were examined to determine whether they were lysogenic. Only one variant, namely, *SU*298/536, was found to be non-lysogenic. Somewhat unexpectedly, this colony type was found to be resistant to the phage obtained from the lysogenic cultures. As the somatic antigenic constitution of *SU*298/536 was found by Vincent to differ considerably from that of the original strain *SU*298, the resistance to the phage could possibly be explained in terms of the suggestion by Marshall and Vincent[2] that the possession of a particular antigen is an essential prerequisite to the action of some strains of bacteriophage on *R. trifolii*.

On present evidence, the practical significance of *Rhizobium* – bacteriophage interaction in soils is somewhat questionable. Similarly, lysogenic strains of root-nodule bacteria may be of questionable significance in soils, although it is felt that the inherent resistance of a lysogenic strain to a particular phage would be to its advantage in soils containing such a phage. The occurrence of lysogeny may be of more practical significance where mixtures of strains are used in the preparation of peat cultures for legume inoculation. Both the lysogenic strain *SU*298 and the susceptible indicator strain *SU*297 have been used in mixed cultures in Australia. I have recently demonstrated (unpublished results) that strain *SU*298 dominates strain *SU*297 when they are mixed in peat. Investigations are in progress to determine whether this is due to the susceptibility of *SU*297 to the phage of the lysogenic *SU*298.

K. C. Marshall
Biological Branch, Department of Agriculture,
Sydney, New South Wales.
Aug. 8.

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Deoxyribonucleic Acid Deficiency in the Mature Egg Nucleus of *Aloe davyana* in South Africa

Recently, there have been two or three accounts of deoxyribonucleic acid deficiency in the egg nucleus of both angiosperms and algae. Delay, for example[1], states that the egg nucleus in the oogonium of *Chara* was found to be Feulgen-negative, whereas the antherozoids were Feulgen-positive right up to the commencement of fusion. Rowlands[2] makes a similar observation on the embryo sac of *Vicia* and puts forward a reason for the deficiency. It was felt that it might prove useful to report a like deficiency in *Aloe davyana*.

The material used in the investigation was collected at Mondeor in the vicinity of Johannesburg in August 1954 by Miss D. Dimovic. The time of collection was one of extremely low mean night temperatures.

The development of the embryo sac of *Aloe davyana* has proved to be of the eight-nucleated type in which the antipodals disintegrate very early.

Previously all stages of the young embryo sac had been stained with crystal violet and had stained well, showing good deoxyribonucleic acid content. The mature embryo sacs over three seasons, however, showed only very faint coloration or none, particularly in the case of the egg nuclei. The synergids and central nuclei were darker, but still did not compare with the deep violet of nucellus nuclei. The optimal thickness for sections was found to be 18μ, and crystal violet stained equally well after Navashin and formalin–acetic–alcohol fixatives. After formalin–acetic–alcohol, using hæmatoxylin, which is not specific for deoxyribonucleic acid, the egg nucleus stained well.

Next the Feulgen method was applied, using cold hydrolysis in 5 *N* hydrochloric acid for forty minutes to one hour at room temperature[3]. The same gradation of colour in the embryo sac as mentioned above was observed in each case. Since leuco-basic fuchsin is specific for deoxyribonucleic acid, the pale pink of the mature egg nucleus against the deep red nucellus nuclei may be taken as proof of deficiency. Feulgen–light green staining was used with the same result.

The Feulgen staining was particularly good after Navashin fixative but also strong after formalin–acetic–alcohol.

The Feulgen stain may also be used for the quantitative determination of deoxyribonucleic acid; but this method was not employed during the above investigation.

It was found that the dividing zygote, even in early prophase, showed deep red chromonemata, evidence that deficiency disappears on fertilization.

With both crystal violet and Feulgen staining, the male nuclei lying free in the embryo sac stained very strongly, quite equal to the nucellus in intensity even when in contact with the egg. Actual fusion was not observed. The male nuclei proved to be exceptionally large and were vermiform or spirally curved. No nucleolus was observed.

In an attempt to gain further proof of deoxyribonucleic acid deficiency, methyl green – pyronin staining was applied after acetic alcohol fixation. Methyl green from Grübler (Leipzig) and pyronin from Gurr (London) was used. Unna's mixture, as tried by Darlington and La Cour, and various modifications suggested by Kurnick[4], Taft and Brachet[5], were tried, together with several differentiation media[6]. The dyes were purified by the methods of Sibatani[6].

Unfortunately, although the methyl green (specific for deoxyribonucleic acid) proved satisfactory, the pyronin available was of unknown type and results on the whole were disappointing. With Kurnick's and Brachet's methods, using a differentiating mixture of absolute alcohol 1/*iso*propyl alcohol 1 for as short a time as possible, it was found that egg nuclei stained pale green compared with nucellus nuclei, whereas the male nuclei were very green indeed. The results bear out the supposition of deoxyribonucleic acid deficiency in the egg nucleus, while the male nucleus shows none of these tendencies.

Quite often during methyl green – pyronin staining the synergid cytoplasm, which should have gone red, gave a green stain instead. The same phenomenon was seen using crystal violet, hæmatoxylin and leuco-basic fuchsin, when the synergids stained violet, black and red respectively. Evidence of deoxyribonucleic acid in the cytoplasm was taken to mean that disintegration of the synergid nuclei had resulted in deoxyribonucleic acid escaping into the cytoplasm. Occasionally, using methyl green – pyronin, the egg nucleus stained red.

The evidence for supposed deoxyribonucleic acid deficiency in the mature egg nucleus of *Aloe davyana* can be attributed to: (*a*) masking by some unknown substance; (*b*) conditions at the time of collection; (*c*) actual deficiency.

So far as (*a*) is concerned, it is difficult to reconcile this argument with the fact that semi-specific crystal violet, as well as leuco-basic fuchsin and methyl green, gives evidence of faint staining only, whereas hæmatoxylin shows full staining of the egg nucleus.

If the severe change from day to night temperature during the collecting period affects the egg nucleus, why is the nucellus, subjected to exactly the same conditions, not changed as well? Possibly the egg nucleus and, indeed, the embryo sac in general, is more sensitive than the nucellus nuclei; but one would expect the male nucleus to have the same tendencies.

Neither (*a*) nor (*b*) is an entirely satisfactory answer to the question, and actual deficiency seems more probable at this stage, especially since the Feulgen reaction can be used for the quantitative determination of deoxyribonucleic acid.

Crystal violet staining in this Department of the embryo sac of *Ornithogalum virense* by J. Gafin (unpublished) has shown no deficiency in the egg nucleus of this plant. If *Aloe davyana* is indeed deficient in deoxyribonucleic acid, it is a rare case and certainly merits further investigation.

It should be noted that *Aloe davyana* is a plant which sets seed easily and abundantly.

S. Krupko
A. Denley

Botany Department,
University of the Witwatersrand,
Milner Park,
Johannesburg.
July 25.

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Influence of Day-length on Nodule Formation in *Soja hispida* by a Specific *Rhizobium* Strain

Experiments have been carried out upon the action of day-length on the formation of nodules by a specific *Rhizobium* strain. Two different varieties of *Soja hispida* (Capitole and Kouban 0375) were used. In each case, four series were made: two were exposed to an 8-hr. day, and the other two to a 16-hr. day. Both for the 8- and the 16-hr. day, one group was sown with the specific *Rhizobium*, the other being sown without the *Rhizobium* (control). The temperature of the room was maintained at 20° C. during the whole experiment in the phytotron installation at Liège. Artificial light was given by six fluorescent 'Phytor' lamps at 65 cm. from the soil (4,500 lux at the soil surface).

It was observed that the *Rhizobium* was able to colonize perfectly the roots of plants in the case of the 16-hr. day, whereas for an 8-hr. day colonization remained very feeble.

With a 16-hr. day, heavy and numerous nodules functionally effective, developing a dark red colour in the internal tissue, were obtained. On the contrary, for an 8-hr. day, nodules were rare and very small; the colour of the inside tissue was pink only for the largest of them; in one experiment, there was total absence of nodules with an 8-hr. day (Fig. 1).

Fig. 1. (*A*) Roots of plants in 8-hr. day, without *Rhizobium*. (*B*) Roots of plants in 8-hr. day, with *Rhizobium* (no nodules are formed). (*C*) Roots of plants in 16-hr. day, without *Rhizobium*. (*D*) Roots of plants in 16-hr. day, with *Rhizobium* (heavy and numerous nodules are formed; indicated by the arrows)

It appears that the day-length to which the leaves of the plants are exposed—in other words, the functioning of the leaves—has an influence on nodule formation by a specific *Rhizobium* and specially on the functional effectiveness of the nodules.

Ch. Bonnier
Institut agronomique de l'État à Gembloux.

C. Sironval
Institut de Botanique et Centre de Recherches des Hormones végétales, I.R.S.I.A., Liège.

Sept. 7.

A Biologically Active Fatty-acid in Malvaceae

It has been known for many years that the ingestion by hens of malvaceous plants or crude fats derived from such plants gives rise to pink 'whites' in stored eggs[1]. Schaible and Bandemer[2] showed that the pink discoloration was caused by iron diffusing from the yolk and chelating with the conalbumin of the white. The disorder is accompanied by a putty-like condition of the yolks when the eggs are cold, and affected yolks have a higher water content than normal. The *p*H values of the yolk and white, normally 6·5 and 9·0 respectively, tend to converge. Schaible and Bandemer[2] suggested that the effects of a diet containing malvaceous products could be explained by an increased permeability of the vitelline membrane surrounding the yolk.

Since the active principle in Malvaceae has not hitherto been identified, chemical studies have been carried out on the oils extracted from the leaves and seeds of *Malva verticillata* and *M. parviflora* and from cotton seed (*Gossypium hirsutum*). As oils of malvaceous plants are known to give a positive reaction to the Halphen test[3], attempts were made to isolate the constituent giving rise to this reaction. The biological activity of several fractions of the oil has also been studied. The results show that the factor in malvaceous oils promoting the development of pink whites is an unsaturated fatty-acid, which may be identical with the acid giving the Halphen test.

In each oil tested, the Halphen test was invariably given by the saponifiable fraction. Low-temperature crystallization of the mixed fatty-acids from acetone solutions yielded fractions giving increasingly intense Halphen tests as the saturated and part of the unsaturated acids were removed. Since the acid giving the Halphen test (referred to here as 'Halphen acid') is heat-labile and readily oxidized, separation by fractional distillation of the methyl esters is not feasible. Reversed-phase partition chromatography[4] has been used for separation. After passing the fractions rich in Halphen acid twice through the partition column, further purification was effected by six to ten crystallizations from cold acetone and petroleum ether. The concentration of the Halphen acid in the mixed fatty-acids of *Malva* spp. probably does not exceed 3 per cent.

While it is doubtful whether pure Halphen acid has yet been isolated, the richest fractions have yielded material with the following characteristics: Halphen colour reaction is just detectable at 10 p.p.m.; gentle heating of the acid, with or without alkali, rapidly abolishes the colour reaction; melting point, 10·3–10·5° C.; analysis, C, 77·4; H, 11·9 and O, 11·0 per cent (oleic acid, C, 76·5; H, 12·1; O, 11·3 per cent); iodine value[5], 110·3; apparent molecular weight 283 (oleic acid 282). The infra-red absorption spectra of the liquid acid showed a prominent band at 1,008 cm.$^{-1}$, which is believed to be characteristic of the *cyclo*propane ring[6]. Dijkstra and Duin[7] found that some oils giving the Halphen reaction also showed strong absorption at 1,009 cm.$^{-1}$.

In order to test whether fractions giving the Halphen test contained the biologically active component, 0·2 ml. of a chromatographic fraction rich in Halphen acid (more than 20 per cent) was fed every day for fifteen days to each of four laying hens. Similar amounts of pure oleic acid were fed daily to four control hens. All eggs from the control (oleic acid) pen were normal, whereas 71 per cent of the eggs from hens fed the Halphen acid showed typical pink-white disorder. Some typical results of chemical analyses are given in Table 1.

Table 1. Chemical Analyses of Control and Affected Eggs

Group of hens	*p*H White	*p*H Yolk	Yolk moisture content (per cent)	Iron (μgm./gm. white)	Non-protein nitrogen (mgm./gm. white)
Before feeding					
1	8·72	6·70	51·5	0·31	0·071
2	8·71	6·66	51·6	0·33	0·076
During feeding					
1 Control eggs	8·57	6·46	51·7	0·22	0·078
2 Pink-white eggs	7·52	7·43	54·3	1·38	0·283

For the affected eggs, the results in Table 1 show increased moisture content of yolks, increased iron and non-protein nitrogen content of whites and convergence of the *p*H values of the whites and yolks. It was found that much higher concentrations of amino-acids occurred in the whites of affected eggs than in the controls. Halphen tests on yolk fat extracted from eggs with pink white were strongly positive in 1 : 10 dilutions and slightly positive in 1 : 100, whereas the control yolk fats were negative.

The rate of hæmolysis of sheep erythrocytes by the potassium soap of Halphen acid (concentration 100 p.p.m.) is three times faster than that produced by a similar concentration of potassium oleate. The Halphen acid may therefore have strong surface-active properties.

A fuller account of these investigations will be published elsewhere. They form part of the research programme of the Division of Food Preservation, Commonwealth Scientific and Industrial Research Organization.

F. S. Shenstone
J. R. Vickery

Division of Food Preservation,
Commonwealth Scientific and
Industrial Research Organization,
Homebush,
N.S.W., Australia.

Sept. 1.

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Chromatographic Detection of Free Amino-acids in Normal and Iron-deficient Plants of *Hibiscus esculentus* L.

It has been reported that in iron-deficient plants there is observed an increase of the soluble forms of nitrogen, with a simultaneous decrease of its protein forms[1-3]. This observation was confirmed in the present work, on *Hibiscus esculentus* L., using the standard methods of chemical analysis. However, we have endeavoured to carry out a qualitative examination of the soluble fraction of nitrogen in normal and iron-deficient plants of this species by the application of paper chromatography.

For that purpose, 3–4 gm. of fresh material taken from 35-day old plants was carefully broken up in 80 per cent ethyl alcohol and the crude extract centrifuged for 15 min. at 4,000 r.p.m. The supernatant liquid was then separated by decantation and concentrated by evaporation until its volume was reduced to 1 c.c. From that concentrated extract 0·005 c.c. was used for each chromatogram. Two-dimensional ascending chromatography on Whatman No. 1 paper, 25 cm. × 25 cm. sheets, was adopted, with phenol as solvent for one direction and *n*-butanol/acetic acid/water (4 : 1 : 5) for the other. The position of amino-acids was located by spraying with ninhydrin reagent (0·1 per cent in acetone). The amino-acids were identified by comparing the spots appearing on the chromatograms with those produced by authentic compounds.

In Fig. 1 are shown two chromatograms : (*A*) from an iron-deficient plant ; (*B*) from a normal plant. With regard to the quantity of amino-acids involved, the greater concentration of these acids is clearly observed in the alcoholic extract of the iron-deficient plants, from the size as well as the intensity of the colour shown by the spots. The higher concentration of asparagine is especially remarkable. From the qualitative point of view, the iron-deficient plants contain phenylalanine, serine and probably glycine. Normal plants do not contain detectable amounts of these amino-acids. From the undetermined spots, two were common on both chromatograms, but were more intense on those prepared from iron-deficient plants. One spot appeared only on the chromatogram from iron-deficient plants, while three appeared on those from normal plants only. The location and colour of one of the last three spots coincide with those produced by cysteinic acid.

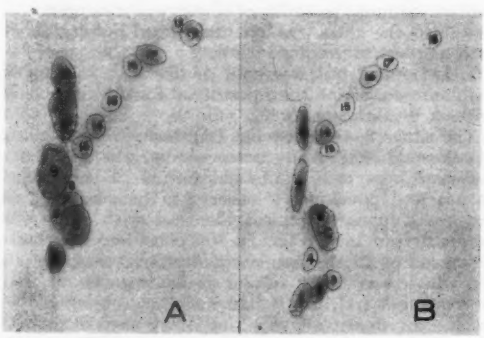

Fig. 1. Two-dimensional ascending paper chromatographs of alcoholic extracts of *Hibiscus esculentus* L. tissue. (*A*) From an iron-deficient plant ; (*B*) from a normal plant.
1, 2, 3, 4, 12, 13, Unidentified spots ; 5, aspartic acid ; 6, glutamic acid ; 7, serine ; 8, glycine (?) ; 9, asparagine ; 10, arginine ; 11, glutamine ; 14, α-alanine ; 15, β-alanine ; 16, tyrosine ; 17, valine ; 18, leucine(s) ; 19, phenylalanine

From these observations, it becomes evident that the difference in the amino-acid content of normal and iron-deficient plants is not only quantitative but also qualitative.

Further details of this work will be published elsewhere.

S. D. Démétriadès
Laboratory of Non-parasitic Diseases,
Benaki Phytopathological Institute,
Kiphissia-Athens.
July 3.

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Chemical Nature of Nucleic Acids in Cyanophyceae

The available information regarding the chemical nature of nucleic acids in Cyanophyceae is very meagre, and deoxyribonucleic acid and ribonucleic acid have not been isolated chemically from this group. As the blue-green cell is peculiar in its nuclear structure, the chemical nature of its nucleic acids may be different in kind or degree from that of other sources. With this in view, the nucleic acids were isolated from *Nostoc muscorum* using the conventional method of Schmidt and Thannhauser as modified by Heinrich *et al.*[1].

The deoxyribonucleic acid separated from *Nostoc muscorum* gives a positive test with the Dische reagent, indicating the presence of deoxypentose-sugar. Chromatographic analysis of the hydrolysate according to the procedure of Wyatt[2] revealed only three spots of bases, corresponding to guanine, adenine and cytosine, but thymine could not be detected. Magee and Burris[3] showed in experiments on nitrogen fixation by *Nostoc muscorum* that incorporation of nitrogen-15 in thymine is much less than that of other nitrogenous compounds. It is possible that the thymine in deoxyribonucleic acid is present in too small an amount to be detected on the chromatogram, and hence application of carbon-14 as a tracer might help its detection. Carbon-14 dioxide was therefore passed through a *Nostoc* suspension in phosphate buffer at *p*H 7 for 6 hr. in presence of light. After the experiment, the suspension was extracted with 80 per cent ethanol, alcohol–ether (3 : 1) and finally with ether only, and deoxyribonucleic acid was precipitated by the procedure referred to above. A radioautograph revealed the spot corresponding to thymine. Added thymine co-chromatographed with the thymine eluted from the radioactive spot. Thus deoxyribonucleic acid in Cyanophyceae is similar in kind to that from other sources, which also support the earlier observations from cyto-chemical work[4] and with the electron-microscope (Singh, R. N., personal communication).

Ribonucleic acid which was precipitated from the deoxyribonucleic acid filtrate by alcohol gave a positive reaction in the orcinol test, indicating the presence of pentose sugar. Chromatographic analysis following the method of Smith and Markham[5] gave four spots corresponding to guanine, adenine, cytidylic acid and uridylic acid. Thus the ribonucleic acid of Cyanophyceae shows no qualitative deviation from the normal type.

Further studies, with carbon-14 and phosphorus-32, on the turnover of nucleic acids in Cyanophyceae are now in progress.

Thanks are due to Dr. D. M. Bose, director of the Bose Institute, for his interest in this work and to Dr. S. K. Roy and Dr. S. P. Sen for suggestions and criticisms.

B. B. Biswas

Bose Institute,
Calcutta 9. Aug. 16.

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Culture of Tubal Mouse Ova

Tubal mouse ova at the eight-cell stage developed consistently to blastulæ, when cultured in the egg white – saline mixture used by Hammond[1] for the actual collection of ova. This fluid was freshly prepared each day and kept in tightly stoppered vessels. Unlike that of Hammond, the *p*H was about 7·0; but this rapidly rose to 7·8 during measurement with a glass electrode or when exposed in shallow vessels, and the change was attributed to loss of carbon dioxide contained in the egg white. Since ova failed to differentiate at a *p*H greater than 7·7, Krebs–Ringer bicarbonate[2] (*p*H 7·4), with 10 γ/ml. penicillin and streptomycin, was adopted as the standard saline medium. With the addition of 1 per cent fresh thin egg white, this proved an excellent culture medium for the ova, but no growth was obtained in the Krebs–Ringer bicarbonate alone.

The essential factor or factors in egg white were shown to be non-dialysable, but an attempt to identify them with one or more of the protein fractions of egg white was unsuccessful. However, normal growth was obtained with Krebs–Ringer bicarbonate plus crystalline bovine albumin (Armour and Armour) in concentrations ranging from 0·03 to 6 per cent, and this preparation was used in all subsequent observations.

Mice were killed on the third day after mating and the ova obtained by inserting a 28-gauge hypodermic needle at the uterine end of the oviducts, and flushing them out into a cavity slide with about 0·5 ml. of the medium. The ova were then collected in about 0·3 µml. of fluid, with as little tubal debris as possible, in a mechanically controlled pipette. They were transferred to a second cavity slide containing 1 ml. of medium, the contents agitated, and the ova again collected with a fresh pipette and transferred to an agglutination tube containing 1 ml. of fluid. This was tightly stoppered and incubated in a water bath at 37° C. After 48 hr. the contents were tipped on to a cavity slide and examined.

Using this technique, only three out of 148 ova failed to develop into blastulæ when cultured in 0·4 per cent bovine albumin in batches of 10–14, and 86 out of 87 developed when the concentration was 0·1 per cent. These blastulæ appeared normal and produced characteristic growth when inserted under the kidney capsule of mice.

It is unlikely that tubal cells or secretions transferred to the culture tubes with the ova played any part in growth, since development continued even if the washing procedure described above was repeated ten times.

The mode of action of the albumin is not clear. It did not appear to function by preventing extraction of any component of the ova, since they failed to grow in Krebs–Ringer bicarbonate containing 200 ova/ml. which had been ruptured by alternate freezing and thawing. However, it did alter the physical properties of the medium and greatly facilitated the manipulation of the ova with a pipette, as those in Krebs–Ringer bicarbonate alone adhered to the glass. So far it has been shown that the omission of calcium, magnesium, potassium or glucose from the Krebs–Ringer bicarbonate prevented growth, and development was delayed without phosphate. Growth occurred only between *p*H 6·9 and 7·7 and continued when the molarity was reduced to 0·09.

I acknowledge the generous help given by members of the Department of Biochemistry of this University.

W. K. Whitten

John Curtin School of Medical Research,
Australian National University,
Canberra.

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Microbiology of Silage

Although several investigators have studied the micro-organisms present in silage, the various types of organisms and the number of each found in different qualities of silage are rarely given. Preliminary results of a study of the micro-organisms present in grass silage made in four different ways may therefore be of interest.

The silage was made in glass tubes in a manner similar to that described by Allen *et al.*[1], 40 gm. of the grass mixture—perennial ryegrass and white clover—being mown and after treatment being packed into tubes 6 in. × 1 in., care being taken that all the implements used had been previously sterilized. Each tube was immediately closed with an air-tight stopper, and stored at ordinary laboratory temperature for seven weeks, after which the tubes were opened and their contents examined for colour and smell as well as bacteriologically.

Four contrasting treatments were adopted as follows: (*A*) the grass was packed without chopping and without the addition of any water or preservative; (*B*) the grass was chopped into inch lengths but packed without the addition of any water or preservative; (*C*) the grass was left unchopped but sprinkled with sterile water before packing; (*D*) the grass was left unchopped but was well mixed with 0·2 gm. of sodium metabisulphite in powdered form before being packed into the tube.

The silage from treatment (*A*), though made without the addition of any preservative, was still green and had kept well. A slight aroma of a pleasant nature had developed; otherwise the condition of the grass appeared almost identical with what was originally put in. In fact, it was considered the best-preserved of all the four methods. In treatment (*B*) the silage was fairly similar in appearance to that in treatment (*A*), but it had a slightly objectionable smell. In treatment (*C*), the silage turned slightly brown after a few days and when opened it smelt strongly of butyric acid; it was deemed the poorest of all the four silages. In treatment (*D*) the grass had kept well and had a pleasant aroma, but it had developed an unnatural shade of green—a bright

Table 1. *p*H AND LOGARITHM OF THE NUMBER OF BACTERIA PER TUBE* IN THE GRASS WHEN FRESH AND AFTER SEVEN WEEKS IN EACH OF THE FOUR TREATMENTS

	Treatment of grass	*p*H	Total bacteria	Lacto-bacilli	Coli-forms	Anaerobic spore formers
	Fresh	6·2	8·9	0·5	4	3
A	Packed as mown	4·5	7·9	7·4	0	0
B	Packed after chopping	4·1	9·8	7·7	0	0
C	Packed after being sprinkled with sterile water	5·6	7·2	6·2	7	6
D	Packed after addition of sodium metabisulphite	5·4	4·0	1·7	3	0

* Each tube contained 40 gm. of fresh grass.

green as compared with treatment (*A*), which had retained the normal fresh green.

In the bacteriological examination the contents of each tube were ground up with sterile sand, and, by dilution, counts were made of the following: the total number of bacteria growing at 30° C. on tryptone glucose yeast extract agar[2]; lactobacilli on Rugosa's medium at 37° C.[3]; anaerobic spore-forming bacteria in Robertson's cooked meat medium at 30° C.; and coliforms in MacConkey's bile salt broth at 30° C.

Table 1 shows that, comparing the four silages with the fresh grass, there has been a distinct change in the pattern of distribution of the bacterial flora, much more so than in the total number of organisms. The total number of bacteria and the number of lactobacilli were considerably lower in the metabisulphite treatment than in any of the other treatments. The number of coliform bacteria, however, had not been reduced to the same extent. Excess of water (treatment *C*) tends to encourage the coliforms and also the anaerobic spore formers—both undesirable developments. On the other hand, treatments (*A*) and (*B*)—packing without surplus water—have reduced both these developments while at the same time they have favoured the development of the lactobacilli.

Two features stand out here in connexion with the lactobacilli. In the first place, the low number of lactobacilli present in the fresh grass; this is typical of all samples of fresh grass encountered in this work. Secondly, it will be seen that the acidity had developed to a further degree where neither water nor sodium metabisulphite had been added. In these two treatments (*A* and *B*) the lactobacillus had not only increased very considerably but also had become the dominant organism.

These and other results on the microbiology of different silages will be reported in a future publication, when it is hoped to relate the figures found in tube silage to those obtained from similarly treated silage made in ordinary silos. This work is being carried out during the tenure of a Sir James Knott Fellowship; I wish to thank Prof. Martin Jones for his interest and advice.

KATHLEEN J. ANDERSON

Agricultural Botany Department,
King's College
(University of Durham),
Newcastle upon Tyne, 1. Sept. 9.

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'Solubilized' Chemicals for the Control of Plant Nematodes

Staniland and Stone[1] have described the use of 'solubilized' chemicals as nematicides. Laboratory work has been continued by Miss J. K. Bartlett with the aid of a grant from the Agricultural Research Council, and some other aspects of the problem are being studied by Mr. L. E. W. Stone. I have given particular attention to the control of potato eelworm in glasshouse soils. Control of potato root eelworm of a high order has been obtained by watering infested soil with a large volume of various 'solubilized' chemicals. Volumes to the extent of one gallon per square foot are necessary, and care is required in application in order to avoid 'ponding', with consequent uneven wetting of the soil and contained eelworm cysts. Cysts not killed are mainly to be found at the lower depths where soil and cysts are wetter. 'Solubilized' chemicals work best in the higher and dryer levels of the soil, where fumigants are least effective since the drier and more aerated soil does not permit a sufficient concentration of vapour to be retained.

It occurred to me that an efficient economic control of potato root eelworm under glass could probably be achieved by a combination of both methods. It has been found that an injection with DD (dichloropropylene dichloropropane) at the usual rate of 400 lb. an acre can be followed by application of a sufficient volume of 'solubilized' chemical to wet the top 2–3 in. of soil, the amount of liquid for this purpose being 2 gallons a square yard. This treatment has now been tested under commercial glasshouse conditions and has given excellent results.

Dr. B. G. Peters, then head of the Department of Nematology, Rothamsted Experimental Station, very kindly undertook a laboratory experiment whereby the effects of nematicides could be studied in separate 2-in. layers of soil to a depth of 12 in. In this way it was possible to investigate the effects of the two chemicals separately and together. Dr. Peters has shown that the two treatments behave independently and that in combination they are effective. A paper describing this work has been published[2].

The combined DD injection, followed by the application of a nematicidal 'seal', is simple and quick in practice and compares favourably with steam sterilization in efficiency, time and cost. The chemical which has been found most suitable for solubilization, with due regard to nematicidal efficiency and low cost, is a commercial xylenol fraction. The most suitable detergent for effecting solubilization is a commercial brand of the long-chain alkyl sulphate type. It is clear that there is much scope in the use of a variety of tar-distillates; and the finding of even cheaper materials, particularly if cheaper detergents were forthcoming, might well extend the use of the method to open land, particularly in connexion with some of the more profitable crops.

A full account of this work will be published elsewhere.

L. N. STANILAND

Ministry of Agriculture,
National Agricultural Advisory Service,
Government Buildings,
Burghill Road,
Westbury on Trym,
Bristol.
Sept. 6.

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Arresting *Paramecium*

Various devices are employed in an effort to slow down the movements of *Paramecium* for the benefit of first-year students. It seemed worth while to report that the so-called cellulose adhesives are very successful indeed.

The material was prepared from 'Stadex C.A.', a commercial product intended for the use of decorators. Movement was slowed to a convenient rate in a 0·15 per cent solution, and one twice this strength was also useful for demonstrating the twisting and turning movements of which the animal is capable. The animals look perfectly normal in the solutions and their movement is normal though slowed; they are apparently unharmed and have survived for more than two months.

I am given to understand that 'Stadex C.A.' is sodium carboxy methyl cellulose. The results should therefore not have been unexpected, for methyl cellulose has already been used successfully[1]; but as its use does not appear to be widely known, it was thought that the present observations would be of value.

C. Ellenby

Department of Zoology,
King's College
(University of Durham),
Newcastle upon Tyne, 1.
Nov. 2.

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Use of Gold Sols as an Aid to focusing in High-Resolution Electron Microscopy

Although electron microscope contrast may be increased by the use of objective apertures, accurate focusing in thin-section work is still difficult and, in order to obtain an in-focus picture of a particular field, it is very helpful to find a small dense particle, or a hole in the membrane, on which to focus. An obvious solution to this problem is to distribute small dense particles on the specimen.

Birch-Andersen *et al.*[1] have tried using carbon black, but the method is open to two objections: (1) large masses must be deposited on the specimen, and (2) even if only single particles are present, it is necessary to focus slightly off the particle to get an in-focus picture of the section, since the diameter, or edge, of the particle is at a different focal level. This effect is of importance, however, only towards the limit of resolution.

We decided that a gold sol might provide particles of useful size and density. Fortunately, it is easy to make gold sols in a wide range of particle sizes. We have found that particles of 130–150 A. diameter are very useful for focusing at a magnification of 9,000; for higher magnifications, smaller particles would be useful.

Turkevich, Stevenson and Hillier[2] described a method of making gold sols in a range of particle sizes. The method (reduction of acid gold chloride, 95 ml. of which contained 5 mgm. of gold, with 1 per cent sodium citrate at 60–100° C. depending on the particle size required) is easy, and yields sols with a very small scatter of particle diameter—the standard deviation of the distribution is about 10 per cent. We diluted the sol 1 in 10 and put drops on mounted sections, left them for 10 min., and then drained off as much as possible. The particles were rather more evenly spread over the specimen if the sol was put on the 'Formvar' membranes before mounting the sections.

We have found that gold sols, prepared in this way, have several advantages: (1) they are extremely dense and give very good images when in focus; (2) they are so uniform in size and their density is so great that they are unlikely to be confused with any tissue components; (3) the size of the particles and their number on the specimen can be varied to suit any particular purpose.

T. H. Flewett
Pamela Tymms

University of Leeds,
School of Medicine,
Leeds, 2.
July 29.

[1] Birch-Andersen, A., Maaløe, O., and Sjöstrand, F. S., *Biochim. Biophys. Acta*, **12**, 395 (1953).
[2] Turkevich, J., Stevenson, P. C., and Hillier, J., *Disc. Farad. Soc.*, **11**, 55 (1951).

Quotation of Titles of Papers in Review Articles

As one of the contributors to the "International Review of Cytology", vol. 3, reviewed in *Nature* of October 8 (p. 664) by Dr. D. R. Newth, I should like to direct attention to certain facts. Dr. Newth concludes his review with the words: "The reviewer of Vol. 1 pleaded for titles of papers to be given in the lists of references. If a reminder will strengthen the editors' hands in forcing this reform upon unwilling authors, it is gladly given".

My review was submitted with a bibliography including full titles, and I strenuously urged the publishers to include them. The following is a quotation from a letter from me to the publishers, dated March 29, 1954: "In a letter to Dr. Bourne [one of the editors] last year, I quoted the review of Dr. E. N. Willmer in 'Nature', in which he strongly deplored the omission of titles of papers referred to in the IRC. A very great deal of the value of any review article is lost if the full bibliography is omitted, and I would have wished to place this review elsewhere had I thought that this grave and short-sighted defect was to be repeated in vol. III. I feel most strongly that the main use of most reviews lies in the bibliography; many of the references I quote are of little use to the reader if he cannot refer to their titles easily, and would not have been included had I known that the titles were to be cut out".

The publishers replied on April 7, 1954: "With respect to the omission of titles of papers, we regret that we will be unable to insert them. It is our house style and also the style of this series, and we have found that on the rare occasions when we have made exceptions we have had unfavorable comments from reviewers concerning the inconsistency. We hope that you will not find this unreasonable".

The editors' hands indeed need strengthening; but not against unwilling authors.

Charity Waymouth

Roscoe B. Jackson Memorial Laboratory,
Bar Harbor, Maine.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 16

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (joint meeting with the INSTITUTION OF CIVIL ENGINEERS and the INSTITUTION OF MECHANICAL ENGINEERS, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Meeting on "Advanced Courses for Engineers in Industry".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Lesser Free Trade Hall, Manchester), at 5.45 p.m.—Mr. Max Beloff: "Benjamin Franklin: International Statesman" (Franklin Memorial Lecture).

INSTITUTE OF METAL FINISHING (joint meeting with the INSTITUTE OF SEWAGE PURIFICATION, at Imperial College, South Kensington, London, S.W.7), at 6.15 p.m.—Mr. A. E. J. Pettet: "The Effects of Metal Finishing Wastes on Sewage Purification".

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Mr. N. S. Sutherland: "Visual Discrimination in Octopus".

Tuesday, January 17

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "A Biologist's Impressions of Brazil".*

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. B. Folkow (Gothenburg): "Quantitative Aspects of some Mechanical, Nervous and Humoral Factors Controlling the Cardiovascular System".*

SCIENTIFIC FILM ASSOCIATION (in the Mezzanine Cinema, Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Mr. R. Ollerenshaw: "The Use and Abuse of Film in Medical Illustration".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. W. Deck: "Crack Detection in Aircraft Structures".

Wednesday, January 18

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. E. N. da C. Andrade, F.R.S.: "Benjamin Franklin in London" (Trueman Wood Lecture).

PHYSICAL SOCIETY, COLOUR GROUP (at Imperial College, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Mr. J. M. Adams: "Colour Half-Tone Printing".

BRITISH GLACIOLOGICAL SOCIETY (joint meeting with the ROYAL METEOROLOGICAL SOCIETY, at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Meeting on "Snow Accumulation and Ablation".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Prof. E. S. Pearson, C.B.E.: "Some Aspects of the Geometry of Statistics: The Use of Visual Presentation in Understanding the Theory and Application of Mathematical Statistics" (Presidential Address).

BRITISH NUCLEAR ENERGY CONFERENCE (in the Great Hall of the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. W. B. Hall and Mr. T. I. M. Crofts: "The Use of Sodium and Sodium Potassium Alloy as a Heat-Transfer Medium".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "The Personality Characteristics of Parents of Promising Children". Speakers: Miss Elizabeth Tylden, Miss Mildred Creak and Mr. S. G. Singleton.*

INSTITUTE OF FUEL (joint meeting with the COKE OVEN MANAGERS' ASSOCIATION (SOUTHERN SECTION), at the Waldorf Hotel, Aldwych, London, W.C.2), at 5.30 p.m.—Mr. L. J. Clark: "Steam and Power in the Gas and Coking Industry".*

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, at the Institute of Metals, 4 Grosvenor Gardens, London, S.W.1), at 6.30 p.m.—Dr. H. J. Plenderleith: "Science in the Service of Archæology".

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. M. R. Mills: "The Selective Hydrogenation of Tung Oil".

Thursday, January 19

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. D. J. Stenning: "Following the Clouds: Sudanese Nomadism".*

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Scientific Papers.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. H. A. Graves: "A Decade of Progress in Canadian Mining (1945–1954)—Part 2".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. R. W. Butcher: "Marine Microflagellates—a Long Overlooked Ecological Group"; Miss P. Lamplugh Robinson: "The Mesozoic Fissures of the Bristol Channel Area and Their Vertebrate Faunas".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. K. F. Roth: "Rational Approximations to Algebraic Numbers".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall, Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 6 p.m.—Meeting on "The Use of Pulverised-Fuel Ash". Mr. B. Butterworth: "Brick Making"; Mr. W. Kinneburgh: "Light-Weight Aggregate".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Dr. G. W. Kenner: "Recent Progress in the Chemistry of Peptides" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Symposium on "The Treatment of Human Amœbiasis". Opening Speakers: Prof. A. W. Woodruff and Dr. A. R. D. Adams. Chairman: Prof. R. M. Gordon.

Friday, January 20

BRITISH SOCIETY OF RHEOLOGY (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 9.45 a.m.—Symposium on "Rheology of Proteins".

BRITISH SOCIETY FOR RESEARCH ON AGEING (in the Littlewood Hall, The General Infirmary, Leeds), at 2.30 p.m.—Meeting on "Connective Tissue and its Changes With Age".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion—"Irregular Changes in the Rotation of the Earth". Chairman: Sir Harold Spencer Jones, F.R.S. Speakers: Mr. T. Gold, Dr. W. H. Munk and Prof. S. K. Runcorn.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—"Some Meteorological Aspects of High-Level Navigation". (1) Captain B. C. Frost: "Jet Streams in Flight"; Mr. J. K. Bannon and Mr. T. H. Kirk: "Forecasting Jet Streams".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. A. W. Davis: "Marine Reduction Gearing" (Thomas Lowe Gray Lecture).

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Mr. E. Chadwick: "Solvents in the Chemical Industry".

Saturday, January 21

BIOCHEMICAL SOCIETY (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN MECHANICAL or PRODUCTION ENGINEERING, ASSISTANT LECTURER IN MATHEMATICS, DEMONSTRATOR IN MECHANICAL ENGINEERING, and a DEMONSTRATOR IN ELECTRICAL ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (January 18).

SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in physics or chemical engineering) with the Ministry of Supply at Waltham Abbey, Essex, for research on heat transfer phenomena at high temperatures—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.458/5A/VD (January 21).

BRITISH COKE RESEARCH ASSOCIATION FELLOW (honours graduate in chemistry, physics or applied science relating to fuel technology) to work on the physical chemistry of carbon under the direction of the Professor of Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (January 31).

CHAIR OF EDUCATION—The Registrar, University College, Singleton Park, Swansea (January 31).

GEORGE ANGUS STUDENT (graduate of an approved university or holder of approved qualifications) for research in the Department of either Chemistry, Physics or Mechanical Engineering—The Registrar, King's College, Newcastle-upon-Tyne (January 31).

LECTURER (with qualifications in theoretical physics) IN PHYSICS—The Secretary, Queen's University, Belfast (January 31).

PROFESSOR OF HEAT ENGINES—The Dean, Faculty of Engineering, Cairo University, Giza, Egypt (February 1).

SENIOR LECTURER IN EDUCATION at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 4).

ASSISTANT LECTURER IN HISTOLOGY in the Department of Physiology and Histology—The Registrar, The University, Liverpool (February 6).

LECTURER IN FUEL TECHNOLOGY in the Department of Chemical Engineering—Head of the Chemical Engineering Department, Imperial College, London, S.W.7 (February 6).

LECTURER or ASSISTANT LECTURER (with some experience in any of the branches of electrical engineering) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Manchester (February 11).

DIRECTOR OF RESEARCH—The Secretary, British Scientific Instrument Research Association, Sira, South Hill, Chislehurst, Kent (February 14).

ASSISTANT LECTURER (honours graduate) IN ZOOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (February 15).

READER IN AERONAUTICS at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 16).

LECTURER IN THE DEPARTMENT OF AERONAUTICAL ENGINEERING—The Registrar Queen Mary College (University of London), Mile End Road, London, E.1 (February 21).

LECTURER IN ASTRONOMY—The Registrar, The University, Manchester 13 (February 28).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY or PHYSICS—Secretary of University Court, The University, Glasgow (February 29).

LECTURER IN ANATOMY—The Secretary, The University, Aberdeen (March 1).

ASSISTANT DIRECTOR (with a good science degree and a knowledge of research in nutrition, and preferably proficient in foreign languages, and experience overseas) OF THE COMMONWEALTH BUREAU OF ANIMAL NUTRITION, Rowett Research Institute, Aberdeenshire—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (May 31).

AERODYNAMICIST (with a first- or second-class honours degree in physics, mathematics or engineering) at the Ministry of Supply Headquarters, London, for assessment of civil aircraft projects for commercial operations, including estimation of aircraft performance during take-off, landing and in flight—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.952/5/AA.

ASSISTANT (preferably with a biological degree and bibliographical experience, and with some knowledge of German) to prepare a journal comprising an annual record of the contents of entomological publications—Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

ASSOCIATE PROFESSOR OF MATHEMATICS—Dean W. H. Johns, Faculty of Arts and Science, University of Alberta, Edmonton, Alberta, Canada.

ENGINEER or PHYSICIST (with a first- or second-class honours degree or equivalent, and keen on practical as well as theoretical work) IN THE INSTRUMENTATION AND PHOTOGRAPHIC DEPARTMENT of the Royal Aircraft Establishment, Farnborough, Hants, for work on development of new and adaptation of existing aircraft automatic pilots—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.620/5A/AA.

HEAD OF THE SCIENCE DEPARTMENT, Grade II—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

MASTER to teach Chemistry up to "A" level—The Headmaster, Worksop College, Notts.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics and considerable experience in electronic techniques), to co-operate with Nuclear Physicists in the design of specialized equipment and circuitry required in nuclear physics experiments with particle accelerators, and to supervise its construction—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 857/34.

SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in electrical engineering or physics with a bias towards electronics, and preferably with previous experience of airborne radar systems) at a Royal Air Force Establishment in Norfolk, for development and adaptation of radio equipment pulse techniques, including aerials, power supplies and displays—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.598/5A/AA.

SENIOR TECHNICIAN to take charge of Aerobic Vaccine Production and Media Making—The Head, Bayer Biological Institute, Beechwood House, 44 Church Street, Exning, near Newmarket, Suffolk.

TECHNICIAN (with experience in clinical biochemistry or in biochemical research) IN THE CLINICAL RESEARCH LABORATORY—The House Governor, Royal Marsden Hospital, Fulham Road, London, S.W.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. A Brief Review of Science and Technology in Western Germany. Pp. viii+103. (London: H.M. Stationery Office, 1955.) 4*s*. net. [811

Ministry of Fuel and Power. Safety in Mines Research Establishment. Thirty-third Annual Report on Safety in Mines Research, 1954. Pp. 93+4 plates. (London: H.M. Stationery Office, 1955.) 4*s*. net. [811

Department of Scientific and Industrial Research. Bulletin of the Geological Survey of Great Britain, No. 9. Pp. iv+58+3 plates. (London: H.M. Stationery Office, 1955.) 6*s*. net. [911

Birkbeck College (University of London). Calendar for 1955–1956 (133rd Session). Pp. 132+xxviii. (London: Birkbeck College (University of London), 1955.) [911

Ministry of Agriculture and Fisheries. Bulletin No. 146: Poultry Breeding—Genetics and System of Breeding. By G. E. Mann. Pp. vi+150. (London: H.M. Stationery Office, 1955.) 4*s*. 6*d*. net. [911

Other Countries

Museum of Applied Science of Victoria. Report of Activities for the year ended 30th June, 1954. Pp. 15. (Melbourne: Museum of Applied Science of Victoria, 1955.) [411

South Australia. Institute of Medical and Veterinary Science. Sixteenth Annual Report of the Council, July 1953–June 1954. Pp. 107. (Adelaide: Institute of Medical and Veterinary Science, 1955.) [411

Defence Research Board, Canada. Publication T53J: Daily Disturbance Variation of Earth Currents at Kakioka. By Kazuo Yanagihara. (Translated by E. R. Hope, with Translator's Comments.) Pp. ii+12. Publication T190R: Earth Currents. By V. A. Troyickaya. (Translated by E. R. Hope.) Pp. 8. Publication T174R: The Ivanov-Troyickaya Earth Current Oscillations. Three papers by A. G. Ivanov and Troyickaya. (Translated by E. R. Hope, with Translator's Comments.) Pp. i+31. (Ottawa: Defence Scientific Information Service, Defence Research Board, 1955.) [411

British Guiana. Geological Survey Bulletin No. 26: The Bauxite Resources of British Guiana and Their Development. Compiled by D. W. Bishopp from reports by E. E. Winter, Sir John Harrison, and from other sources. Pp. i+123+9 figures. (Georgetown: Geological Survey, 1955.) 12*s*. 6*d*. [511

United States Department of Agriculture. Index-Catalogue of Medical and Veterinary Zoology. Part 1: Authors—Aall to Azzolina. Pp. 1–142. Part 2: Authors—B to Bychkov. Pp. 143–612. Part 3: Authors—C to Czygan. Pp. 613–962. 40 cents. Part 4: Authors—D to Dzunkovski. Pp. 963–1176. 30 cents. Part 5: Authors—E to Fynney. Pp. 1177–1458. 45 cents. Part 6: Authors—G to Gyser. Pp. 1459–1754. 40 cents. Part 7: Authors—H to Juzuki. Pp. 1755–2272. 1.25 dollars. Part 8: Authors—K to Kyzer. Pp. 2273–2582. 55 cents. Part 9: Authors—L to Lyutkevich. Pp. 2583–2966. 70 cents. Part 10: Authors—M to Myoh. Pp. 2967–3482. 1.50 dollars. Part 11: Authors—N to Ozzard. Pp. 3483–3720. 75 cents. Part 12: Authors—P to Quortrup. Pp. 3721–4054. 1 dollar. Part 13: Authors—R to Rzoska. Pp. 4055–4348. 1 dollar. Part 14: Authors—S to Shweig. Pp. 4349–4676. 1.25 dollars. Part 15: Authors—Si to Szyszowski. Pp. 4677–4986. 1.25 dollars. Part 16: Authors—T to Tsykalas. Pp. 4987–5210. 1 dollar. Part 17: Authors—U to Wyville. Pp. 5211–5608. 1.25 dollars. Part 18: Authors—X to Zyukov. Pp. 5609–5711. 40 cents. Supplement 1: Authors A–B. Pp. 1–317. 1 dollar. Supplement 2: Authors A–C. Pp. 318–458. 50 cents. Supplement 3: Authors A–I. Pp. 459–844. 1.25 dollars. Supplement 4: Authors A–K. Pp. 845–970. 45 cents. (Washington, D.C.: Government Printing Office, 1932–1955.) [511

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 36, No. 9: Gains in Longevity Are Countrywide. Pp. 12. (New York: Metropolitan Life Insurance Company, 1955.) [811

Department of Agriculture, Mysore State. Entomology Series—Bulletin No. 16: A List of the Insects of Mysore including the Mites. By S. Usman and Dr. M. Puttarudraiah. Pp. vi+194. (Bangalore: Government Press, 1955.) Rs. 1/9/–. [811

Rensselaer Polytechnic Institute. Bulletin, Vol. 54, No. 3: The Writings of David Barnard Steinman relating to the Design, Construction and History of Bridges, including Contributions to the Development of the Engineering Profession, 1909–1954—a Bibliography. Prepared by the Staff of Rensselaer Polytechnic Institute Library. (Engineering and Science Series, No. 67.) Pp. 28. (Troy, N.Y.: Rensselaer Polytechnic Institute, 1955.) [911

Université de Thessaloniki: Laboratoire de Zoologie. Observations suivies sur la Montée en Grece. 2: Pendant les années 1940–41 jusqu à 1948–49. (Montée, Anguilliculture, Inanition.) Par Prof. G. D. Athanassopoulos. Pp. i+80. 3: Pendant les années 1949–50 jusqu à 1954–55. (Montée, Arguilliculture, Inanition.) Par Prof. G. D. Athanassopoulos. Pp. 80. (Thessaloniki: Université de Thessaloniki, 1955.) [911

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 113, No. 7: The Fossil Salamanders of the Family Sirenidae. By Coleman G. Goin and Walter Auffenberg. Pp. i+497–514. Title Page and Index to Vol. 113. Pp. 3. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1955.) [911

United States Department of Agriculture. Leaflet No. 389: Cantaloup Insects in the Southwest: How to Control Them. Pp. 8. 5 cents. Leaflet No. 392: Fleas: How to Control Them. Pp. 6. 5 cents. (Washington, D.C.: Government Printing Office, 1955.) [911

Museum of Comparative Zoology at Harvard College. Breviora. No. 47 (July 12, 1955): A New Species of Whiptailed Lizard (Genus *Cnemidophorus*) from the Colorado Plateau of Mexico, New Mexico, Colorado, and Utah. By Charles H. Lowe, Jr. Pp. 9. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1955.) [911

United States Department of Commerce: Weather Bureau. Research Paper No. 38: Evaporation from Pans and Lakes. By M. A. Kohler, T. J. Nordenson and W. E. Fox. Pp. iv+21. (Washington, D.C.: Government Printing Office, 1955.) 20 cents. [911

International Survey of Programmes of Social Development. Prepared by the Bureau of Social Affairs, United Nations Secretariat, in co-operation with the International Labour Office; the Food and Agriculture Organization; the United Nations Educational, Scientific and Cultural Organization; and the World Health Organization. Pp. iv+220. (New York: United Nations; London: H.M. Stationery Office, 1955.) 2 dollars; 15*s*.; 8 Swiss francs. [911

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